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Astronomy and Internationalism

Many writers of the present day are accustomed to attempt to discover the bearing of the interests and activities of various groups of persons, the world over, upon the interests and welfare of the peoples of the world as a whole. In some cases such interaction is obscure or very slight or even non-existent; in others it is clearly evident, extensive, and potent.

The number of persons in the civilized world engaged in astronomical study and investigation is very small in comparison with some other groups. But the influence of this group, actual or potential, in international relationships is very much greater than would be implied in a merely numerical comparison. The indispensable foundation for a secure and satisfactory internationalism is more rather than less of international intercourse and understanding. This is promoted in an unusual degree by the nature and the demands of astronomical science.

Most aspects of human undertaking must be expanded in order to make them international; astronomy, however, must be contracted to bring it within the scope of that term as it is here used. The domain of astronomy is extra-mundane, and workers in this domain must rise above all international and artificial boundaries in order to reach the plane of common endeavor. Again, the problems for which astronomy seeks solutions are so vast and so far-reaching that workers in one nation as a rule, are not able to cope with them. They demand the combined efforts of all and thus stimulate international coöperation.

This astronomical internationalism is given concrete expression every three years in the assembly of The International Astronomical Union. Inaugurated in 1904, dormant from 1914 to 1919, revived in 1919 under a name slightly different from the original one, it is now a vigorous and effective organization astronomically and, incidentally, socially and politically. It has clearly demonstrated that community of interest engenders community of spirit.

Although astronomy cannot be said to have a common vernacular, nevertheless, just beneath the surface there lies a common language.

In the spirit of this common language, we, at the beginning of a new volume, extend greetings to our readers in so-called foreign lands as well as to those in our own, and wish for all, in the new year of 1936, substantial progress toward the attainment of their cherished ideals.

Meteor Craters

By FLETCHER WATSON, Jr.

During the past few years the discovery of several large meteor craters has resulted in a renewed interest in meteorites and in considerable speculation regarding the mechanics of the formation of meteoritic craters and the shapes which they may have. The purpose of this paper is to examine the information about the several craters known to be of meteoritic origin and to see what generalizations can be made. We shall first review the salient facts about each of these craters.

Arizona Crater

The Meteor Crater in Arizona is the largest of this type of depression known. It is approximately round, and averages about four thousand

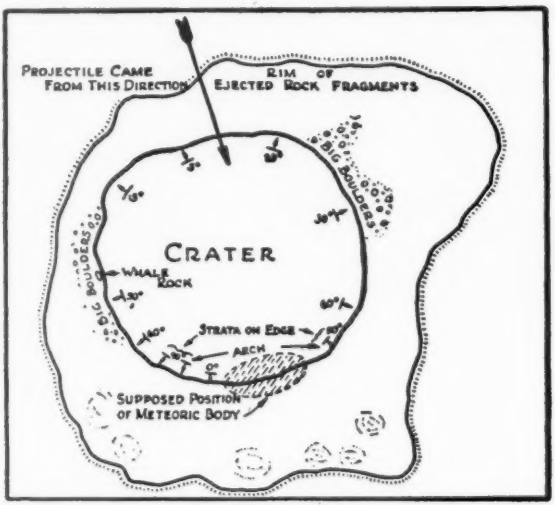


Figure 1
Outline Map of Arizona Meteor Crater showing Angles of Slope of Crater Walls.
Reproduced by permission of *Scientific American.*

feet in diameter and five hundred and seventy feet in depth.[1] Several thousand pieces of meteoritic iron, one of which weighs 1,014 pounds, have been found on the surrounding plain. Assays of these meteorites have revealed a trace of the rare and valuable metals, platinum and iridium. The value of these two metals, and of the nickel (about seven

[1] Daniel Moreau Barringer, *Proc. Acad. Natur. Sci. Phila.*, p. 556, Sept., 1914.

per cent of the composition), and iron (about ninety-two per cent) aroused an interest in prospecting for any large mass which might be buried under the crater. To determine the rock structure below the crater and the position in which such a mass might lie, several drill holes were sunk. The first drillings were made through the floor of the crater. They showed that the deep rock strata beneath the crater were undisturbed. The first of these undisturbed strata lies approximately two hundred feet under the northern part of the crater, but at a depth of eight hundred feet[2] under the southern part. An inspection of the visible crater walls reveals that the exposed strata have been tilted upwards away from the center of the crater (Fig. 1). The least amount

FIGURE 2
AERIAL PHOTOGRAPH OF THE ARIZONA METEOR CRATER AS SEEN FROM SLIGHTLY WEST OF NORTH.
On the far side of the crater may be seen the 2700 foot arched uplift mentioned below.
Reproduced by permission of the U. S. Army Air Corps.

of tilt is found in the northern wall. The slope increases along both the eastern and western walls, until in the southeast and southwest the strata are practically vertical. In contrast to the strata so tilted, and separated from them by an abrupt discontinuity, occurs, along the rim slightly east of south, a broad arch, 2,700 feet long, the almost flat strata of which have been raised vertically about 100 feet (Fig. 2). The arch appears to be a localized uplift possibly due to steam explosion subsequent to the complete deceleration of the penetrating body. The peculiarity of the tilting, combined with the rock structure beneath the

[2] Benj. Chew Tilghman, *Proc. Acad. Natur. Sci. Phila.*, p. 903, Dec., 1905.

crater, suggests that the impact was not vertical, as previously supposed, but at a considerable slant from the north.

To test this theory of the direction of impact, a churn-drill was put down through the center of the arch in the south rim of the crater wall. Below a depth of twelve hundred feet the drill passed through a region increasingly rich in loose meteoritic material and finally struck at 1,340 feet a region very rich in nickel-iron and exceedingly resistant to boring. The drill was slowly forced through thirty feet of this material, but it stuck and remains completely immovable at 1,376 feet. The behavior of the drill shows that the meteoritic penetration continued to a depth of over 1,300 feet, and also that very probably a portion of the original mass lies buried beneath the southern rim of the crater (Fig. 3).

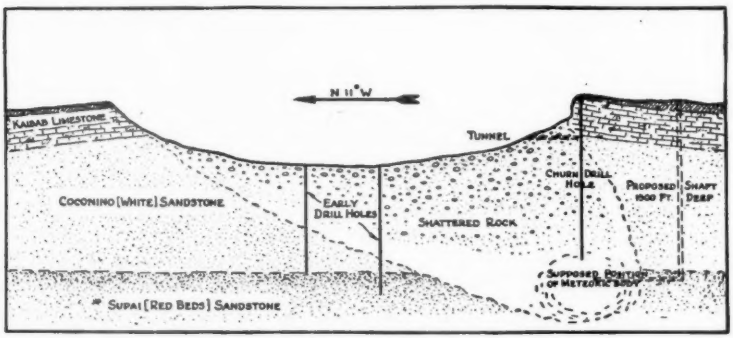


FIGURE 3
CROSS-SECTION OF METEOR CRATER THROUGH THE BROAD ARCH, SHOWING PROBABLE INTERNAL STRUCTURE.
Reproduced by permission of *Scientific American*.

From the position of this mass, the various depths of the undisturbed strata under the crater, and the symmetrical tilting of the crater walls around a north-south axis, it was concluded by the Barringers and their associates that the body struck from the north at an angle of approximately forty-five degrees.[3,4]

WABAR CRATERS

In February, 1932, Mr. H. St. J. B. Philby discovered two meteor craters among the sand dunes in the Great South Desert of Arabia.[5] Several pieces of meteoritic iron and numerous "silica bombs" containing microscopic globules of meteoritic iron were found near the craters; their classification as meteoritic therefore seems indisputable. The larger crater is described as "approximately circular" with a diameter of 330

[3] Daniel Moreau Barringer, *Meteor Crater*, a paper read before the Nat. Acad. Sci., November 16, 1909.
[4] D. M. Barringer, Jr., *Scientific American*, **137**, 52-54, 144-146, 244-246, 1927.
[5] L. J. Spencer, *Mineralogical Magazine*, **23**, 388, 1933.

feet and a depth of forty feet. The smaller crater is roughly oval with axes of 180 and 130 feet. In the vicinity are two other depressions suspected of being meteoritic in origin, but they are not yet accepted as such.

Henbury Craters

Near Henbury, in the center of Australia, a group of thirteen meteor craters was found in 1931. The region was first investigated by A. R.

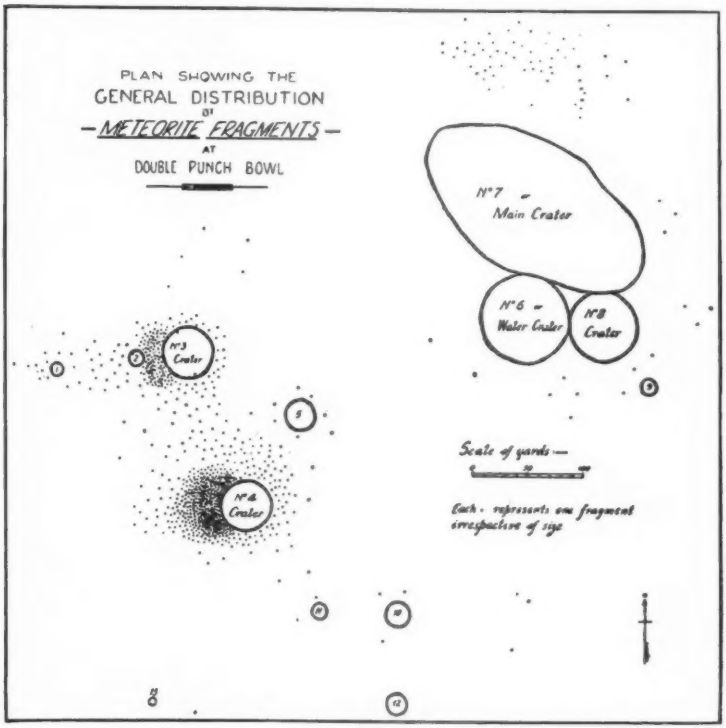


Figure 4
Map showing Distribution of the Craters and Meteoritic Fragments at Henbury.
Reproduced by permission of *Mineralogical Magazine.*

Alderman, who conclusively showed that the craters are meteoritic.[6] Twelve of the craters are roughly circular, and their diameters vary from about 30 to 260 feet. The largest crater is oval with axes of 660 (NW - SE) and 360 feet. This oval crater seems to deviate from the common circular shape of the others, and it may have been formed by

[6] A. R. Alderman, *Min. Mag.*, **23**, 19-32, 1932.

the simultaneous impact of two large bodies near together. A large number of meteoritic irons have been found around the craters. Also, for the first time, a considerable amount of meteoritic iron was found under a meteor crater:[7] four fragments, the weathered remains of one piece with a total weight of 441 pounds, were found ten feet below the ground level or seven feet below the bottom of the small crater (known as No. 13), which is the smallest of the group and has a diameter of only thirty feet (Fig. 4).

The distribution and structural nature of some of the meteorites are unusual. The irons so far discovered were distributed in an uneven fashion around the craters, probably as the result of the differential erosion of the vicinity. In one area, six by six feet near crater No. 4, over a hundred fragments were collected. Such an array of fragments suggests the breaking up of a large mass. However, many of the larger pieces were found one hundred to two hundred yards from the craters, farther than the range of the smaller pieces. These facts, combined with the state of erosion of the craters, have led to a decided disagreement between Alderman and Spencer and R. Bedford, who has also investigated the region,[8] concerning the probable age of the craters.

Dr. L. J. Spencer has pointed out the similarity of structure and composition of the meteoritic irons from Wabar and Henbury.[9] The structure of the crystals is classed as medium octahedral, and they contain 7.3 per cent nickel. The larger pieces from both Wabar and Henbury show the normal octahedral structure, but the smaller pieces show a partial destruction of this crystal structure with granulation of the kamacite, indicating that they have been heated to at least 850 degrees Centigrade—the transformation temperature of alpha-iron to gamma-iron (body-centered to face-centered lattice).

Odessa Crater

Another recent addition to the list of known meteor craters is the Odessa crater in Ector County, Texas. The discovery of a siderite in 1921 by Mr. Arthur B. Bibbins and his subsequent description of the region in which it was found suggested to Mr. D. M. Barringer, Jr., that this might be another meteor crater, perhaps similar to the Arizona crater.[10] In 1926 he visited the site of the crater and found four small pieces of meteoritic iron and much "iron shale," similar to that at the Meteor Crater in Arizona. More recently others have found meteoritic iron in the vicinity, especially Dr. H. H. Nininger,[11] who made an electromagnetic survey of the region in 1933 and collected over 1,500 pieces of magnetic material ranging from less than one to more than

[7] According to L. J. Spencer, *Min. Mag.*, **23**, 391, 1933, found by R. Bedford.
[8] L. J. Spencer, *Min. Mag.*, **23**, 31 and 387, 1933; also R. Bedford, *Nature*, **133**, 575, 1934.
[9] L. J. Spencer, *Min. Mag.*, **23**, 388, 1933.
[10] D. M. Barringer, Jr., *Proc. Acad. Natur. Sci. Phila.*, **80**, pp. 307-311, 1928 (first published report about the crater).
[11] H. H. Nininger, Pop. Astr., **42**, 47, 1934.

fifteen grams. He also found one larger piece weighing about 300 grams.

Monnig and Brown[12] have recently made a plane-table survey of this crater and have determined the contour lines. The crater has been differentially eroded, with the result that the contour lines are rather ragged. However, the surveyors concluded that the original crater was probably circular in shape and about 550 feet in diameter. At the present time it is a shallow basin with a maximum depth of fifteen feet and a low rim two or three feet above the plain. The eroded condition of the crater and the weathering marks on the meteoritic fragments found near it suggest a considerable age.

Craters on the Island of Ösel

A group of five craters and another of six small depressions have been found on the Island of Ösel, in the Baltic Sea off the coast of Estonia. The first group is composed of one large crater, occupied by a lake, and four smaller craters which contain water during at least the rainy season; in the second group are some six shallow depressions possibly related to the first. The main crater has a rim rising about twenty feet above the level of the ground and is nearly circular in outline with diameters of 300 and 360 feet. (These are extreme values, for measurements between the highest points in the crater rim give diameters of approximately 330 feet. The circular shape is sustained by measurements of the diameters of the other contour lines shown in Figure 1 of Reinwaldt's first paper.[13]) Crater No. 1 is circular, with a diameter varying between 110 and 128 feet. Crater No. 2 is definitely elliptical: one end is somewhat deeper than the other, and the contour lines suggest that the depression is really two craters which are so close together that no separating wall exists. Crater No. 3 is circular and has an overall diameter of 106 feet. There is practically no rim around this crater. Crater No. 4 has the characteristic bowl form of the group and is circular in shape with a diameter of 65 feet; on the east side, however, it is abruptly cut off along a straight line. Reinwaldt has excavated this crater very carefully. He has also cut trenches through the walls of the other craters, and has sunk a number of bore holes into the rock strata beneath their surfaces. The results are practically the same for each crater: the limestone strata comprising the walls have been raised, and slope away from the center at angles between thirty and forty degrees. In the jagged edges of the upturned strata are large amounts of pulverized limestone; below, lie strata in their normal horizontal position. The excavation of crater No. 4 revealed a short "funnel" in the rock at the center of the crater. Around this funnel, which is three feet wide and twenty inches deep, the dolomite is cracked and has a burnt appearance (it is a lighter color than the same stratum nearby). Bore holes

[12] O. E. Monnig and R. Brown, Pop. Astr., **43**, 34, 1935.

[13] I. Reinwaldt, *Pub. Geol. Inst. Univ. Tartu*, No. 11, 1928 (first paper), and No. 30, 1933 (second paper).

beneath the crater surface show a region of powdered rock merging into shattered rock in situ, and then undisturbed strata. The description agrees in detail with the general structure of the Arizona crater, with the exception of the arched uplift in the wall of the latter and the evidence of deep meteoritic penetration under the arch. The main crater at Ösel is one-eleventh the size of the Arizona crater; the possibility for deep penetration of a meteorite is much less when a small mass is involved. Reinwaldt has pointed out that the apparent absence of meteoritic material from that region is not surprising, as the soil has been tilled for centuries and any iron would have long since been carried away. The craters are post-glacial, as indicated by their sharp rims and lack of glacial sediments. Although several other possible origins have been suggested for the craters, the meteoritic theory based on the evidence secured by Reinwaldt appears to be decidedly the best.

Siberian Craters

On June 30, 1908, a great meteor swarm blazed over Central Siberia and tore into the earth, destroying a large forest area. After many years, authoritative statements have appeared to supplant the former rumors about the gigantic event. This is the first time that the formation of sizable meteor craters has been observed: we have the date and also some facts about the actual air path of the swarm. Astapowitsch places the radiant in Cetus, less than 45 degrees from the apex of the earth's motion, and at that time ($0^h\ 16^m$ G.C.T, or 7:00 A.M. local time) at an altitude between 4 and 24 degrees above the horizon.[14] The observations indicated that the velocity of the bodies was high, as would be expected from their head-on collision with the earth in its orbit. Furthermore, the reports state that the bodies moved along a straight line,[15] which shows that their course was little affected by atmospheric resistance and that they must have struck the ground at practically the same angle at which they entered the atmosphere. Kulik, who has led in the investigation of the region of impact, found in a marsh at least ten craters with diameters between 33 and 165 feet.[16] His brief description of them states that they are circular.[17] Other articles,[18] perhaps based on a more nearly complete bibliography of the original Russian papers, use the terms "diameter" and "Durchmesser" to describe the measurements, indicating circular shapes; also no mention is made of any ellipticity. It therefore seems proper to describe the craters as at least "roughly circular."

[14] J. S. Astapowitsch, *Russian Astr. Journal*, **10**, No. 4, 465-483, 1933.
[15] A. V. Vosnesersky, *Mirovedenie*, No. 1, p. 25, 1925, verbal translation from the Russian by Dr. Sergei Gaposchkin.
[16] L. A. Kulik (Stentzel), *Das Weltall*, **28**, 137-150, 1928-29.
[17] D. O. Svyatsky, *Mirovedenie*, No. 6, p. 376, 1928.
[18] L. A. Kulik (Schmid), *Das Weltall, loc. cit.*, and **32**, 95, 1933; also L. J. Spencer, *Nature*, **129**, 783, 1932.

Distribution of Meteor Radiants

Unless the bodies that become crater-forming meteorites move through space in a stream, which seems very improbable, the course of a day should provide every square degree of the observer's sky with the same chance of containing the radiant point of such a body. This hypothesis neglects the influence of zenith attraction (the change of orbit due to the earth's attraction) and air resistance, both of which will be small for a body with the mass and velocity of the kind we are considering.[19] We can therefore expect only a very few of these bodies to descend nearly vertically: about one-fourth should strike at angles less than 35 degrees, and one-half at angles greater than 60 degrees with the vertical.

Conclusions

The foregoing observational facts show that in each of the six falls examined the craters are predominantly round, at least "roughly circular." The circular form of individual meteor craters has been noted by Barringer, Spencer, and others. From the probable distribution of radiants we might expect that only two of the six bodies would descend at angles less than 35 degrees with the vertical. Moreover, we know with practical certainty that two of them struck the earth at large angles with the vertical: the Arizona meteor at about 45 degrees, and the Siberian meteors at not less than 66 degrees. Thus we have circular craters from meteorites which struck with directions other than the vertical and even approaching the grazing angle. We see that the soil has little to do with the crater shape, for we have craters in sandstone, limestone, and in a marsh, yet the "roughly circular" shape is found in each of the instances considered. Speculations that grossly elliptical craters are formed by the non-vertical impact of meteors must apparently be set aside until some *meteoritic evidence* is produced to support such hypotheses.

The Formation of Meteor Craters

The preceding comments on the structure of six meteor craters or groups of craters naturally lead to some remarks about the processes by which they were formed. There are two theories of formation which have been held by various authorities on meteors:[20] 1) the "plowing theory," which requires that the crater be caused by the actual gouging out of the earth by the meteoritic mass, and 2) the explosion theory. The former is based on analogy with the pits formed by small meteorites, which are simply gouged holes. In this theory a very large mass with great kinetic energy is required to dig out a meteor crater of the size that is found—several million tons would have been necessary for the Arizona crater[21] and about forty thousand tons for the Siberian craters.

The second theory requires an explosion. The heat developed at the

[19] C. C. Wylie, Pop. Astr., **41**, 211, 1933.
[20] C. C. Wylie, Pop. Astr., **42**, 469, 1934.
[21] D. M. Barringer, *Proc. Acad. Natur. Sci. Phila.*, pp. 558-561, Sept., 1914.

impact is so great that part of the meteoritic material is vaporized, expanding with explosive force sufficient to form the craters and to send out a "tidal wave" of air and shower of debris. On this theory the mass required is much smaller—less than one hundred thousand tons for the Arizona crater and only about two hundred tons for the Siberian craters.

A cap of hot compressed air will be formed in front of any large meteorite and will have an important effect at the time of the impact with the ground. At present it is observationally impossible to do more than suggest the effect that such an air cap might have. When the impact occurs, the air cap will be trapped between the ground and the descending meteorite, and will be still more highly compressed. There will be some plowing effect, as suggested above, and a great expansion outward, both horizontally and vertically.[22] Perhaps it is this upward expansion, with the consequent decrease of pressure on the ground, which gives the craters their round shape. The impact of the solid body and the meteoritic explosion are almost simultaneous. The barometric variations as recorded at a distant station should show the passage of several pressure waves, one from the air cap and one or more from the explosion of the solid body. The air cap is important only during the beginning of the eruption and in the destructive outward and upward blasts.

That this series of events approximately represents what occurs is shown in the Siberian fall, for which the computations based on earth-wave energy and ground-wave energy show that approximately 10^{21} ergs of work were released by the explosion.[23] The size of the explosion is indicated by the pillar of smoke and debris which shot up to a height of twelve miles and was visible at a distance of 250 to 300 miles. About 3,000 square miles of forest were burned or the trees blown over by the horizontal blast. It even caused detectable barometric variations in England, 3500 miles distant.[24]

Dr. L. J. Spencer has given a graphic picture of the formation of meteor craters, based on his study of the craters and the "silica bombs" from Wabar.[25] These chunks of frozen silica foam include many microscopic spheres of nickel-iron which chemical analyses show to be of meteoritic origin. They are part of the nickel-iron vapors of the explosion which condensed and were trapped in the boiling desert sand. The tiny liquid spheres sped through an atmosphere which contained very little oxygen; otherwise they would have been oxidized, at least in part, and would not have the shiny surfaces they now exhibit. The silica was not only melted, but vaporized, for the surfaces of the "bombs" show dew-like drops of condensed silica. It is possible to set up a theoretical "geological thermometer" by which the "temperatures" present during

[22] See suggestion of H. N. Russell in appendix to reference (1).
[23] J. S. Astapowitsch, *Russian A. J.*, **10**, No. 4, 465-486, 1933.
[24] F. J. W. Whipple, *Q. J. R. Met. Soc.*, **56**, 287-304, 1930.
[25] L. J. Spencer, *Min. Mag.*, **23**, 387-404, 1933.

the explosion may be measured (table after Spencer):

α iron to γ iron	850°
nickel melts	1452
iron melts	1535
silica melts	1710
nickel boils	2900
iron boils	3200
silica boils	3500?

These boiling points are computed for a pressure of one atmosphere and will undoubtedly be higher under the great pressure of the impact and explosion.

An examination of the iron particles found around Wabar and Henbury reveals that the smaller pieces show a much greater γ iron content than do the larger pieces. This is not unexpected: the explosion is almost instantaneous, one great flash of blazing gas, then settling dust and smoke. Since an appreciable time is required for heat to penetrate a large meteorite, only a thin surface layer will be affected by the explosion. A smaller piece has more surface per unit volume and will heat more readily, thus changing its crystal structure. The discovery of a 441-pound piece of iron under the smallest crater at Henbury indicates that it is possible for a part of the original material to remain intact during the formation of the crater.

At the present time it is impossible to make any further generalizations about meteor craters, since we have reliable information concerning only six. In five of the falls we have no conception of the velocity of the particles, and can form only the roughest ideas as to when the craters were excavated and the subsequent erosion and climatic changes which must have taken place. Furthermore, we have no information about the angle at which four of the falls struck. It is, therefore, difficult to make many generalizations from the observation of such a heterogeneous group of objects.

Carolina Bays

The previous pages contain a discussion of the observed features and the probable origin of the largest and most reliably identified meteor craters. Let us now apply these conclusions, deduced in the general case, to the supposed meteoritic origin of the Carolina Bays. The first report of these shallow basins was that of L. C. Glenn, who observed several of them near Darlington, South Carolina, in 1895. A subsequent aerial survey of the Carolina coastal region revealed that these shallow depressions, known locally as "Bays," were scattered over the Carolina lowlands and parts of the neighboring states. The Bays are large: approximately fifteen hundred (one-half of the total number known) are more than a quarter of a mile long, and approximately one hundred exceed a mile in length.[26]

While the Bays are in general of an oval shape, it has been found that

[26] F. A. Melton, *Discovery*, **15**, 151-154, 1934.

the shape varies with the size, the larger being the more elliptical. Furthermore, the long axes of the ovals lie in nearly the same direction: almost due northwest and southeast. These phenomena—the elliptical shapes, the variation of ellipticity with size, and the parallel alignment of the major axes—are the important features which any theory of the origin of the Bays must explain. Several geological theories have been advanced, notably that of wind and wave action in an exposed shallow lake.[27] A prevailing wind, or a very strong wind blowing for short periods, would set up transverse waves, the erosive action of which would tend to elongate the lakes, the largest, over which the wind has the longest sweep, being elongated the most. Sandbars would be built up by the undertow along the windward shores, and these bars would appear as low rims if the lakes were later drained. Before this drainage occurred, the uneven shapes of the original lakes would be smoothed by low sandbars, leaving small satellitic bays often arranged in an echelon fashion. Such wind and wave action is well exemplified by the lakes along the Massachusetts coast.[28]

None of the geological theories, however, were accepted by F. A. Melton and William Schriever, geologists at the University of Oklahoma. They pointed out eight facts of observation which must be explained by any theory for the origin of the Bays. After considering these facts, they proposed a meteoritic theory based on certain broad assumptions regarding the probable behavior of a swarm of giant meteorites striking the ground at a considerable angle. I propose in the following pages to point out the apparent inconsistencies between their assumptions and the observed facts regarding known meteor craters in general.

A rather large number of meteoric irons has been found in the Southern Appalachian Mountain region adjacent to the "Bay country."[29, 30] Various writers have attempted to use the occurrence of these irons as evidence of a great shower of meteorites. If the meteorites result in fact from such a shower, they must (1) have the same terrestrial age as the Bays, (2) be distributed over the same region as the Bays, and (3) be mostly of the same type, for the particles recovered from any one meteorite shower are usually similar.

The age of the Bays is considerable. They were formed prior to the Late Wisconsin Period of the Pleistocene, perhaps ten thousand years ago, and possibly at a much earlier time.[31] Although little is known about the rate of decomposition of meteoritic irons, the process must be stimulated by the considerable rainfall of the region in which these irons

[27] D. W. Johnson, *Science*, **79**, 461, 1934. A personal letter calls attention to the differences between this theory and that of sea-level shore processes in a *marine* lagoon as presented by C. W. Cooke, *Jour. Geol.*, **42**, 88, 1934.
[28] Erwin Raisz, *Jour. Geol.*, **42**, 839, 1934.
[29] C. P. Olivier, *Meteors*, p. 240, 1925.
[30] H. H. Nininger, *Our Stone Pelted Planet*, map, p. 149, 1933.
[31] Melton and Schriever, *Jour. Geol.*, **41**, 52, 1933.

are found. Furthermore, one constituent which causes rapid disintegration of meteoritic irons is Lawrencite ($FeCl_2$) which is found in several of the irons from Tennessee and the Carolinas.

A recent map of the hypothetical outline of the Bay region places the eastern boundary far out in the Atlantic Ocean.[32] The northern and western boundaries are supposed to include parts of Kentucky, Ohio, and practically all of both Virginia and West Virginia. On the other hand, nearly all of Georgia and Central Tennessee is excluded. Nininger's map[33] shows the distribution of the meteorites which are sup-

UNITED STATES
Showing distribution of iron meteorites.
• Irons found
• Irons seen to fall
• Irons of more than a ton
• Iron-stony

FIGURE 5
NININGER'S MAP SHOWING DISTRIBUTION OF IRON METEORITES.
The dashed region is the hypothetical outline (after Melton) of the region of the Carolina Bays.
Map reproduced by permission of Houghton Mifflin Co.

posed to be related to the Bays. A superposition of the maps shows a conspicuous dissimilarity in distribution (Fig. 5). One observed fact which any theory must explain is the probable absence of Bays from the Piedmont upland. It is inconceivable that bodies that could form marks hundreds of yards long, which have remained for thousands of years in a silty soil, could not have had sufficient energy to make marks on a rocky and more enduring surface. Furthermore, it would be necessary for us to believe that these moderate sized meteorites (weighing a few

[32] Melton, *Discovery, op. cit.*
[33] Nininger, *op. cit.*

pounds) are representative of the swarm of bodies supposed to have made the giant scars; or that the irons are the only remains of the giant bodies. There is, however, no evidence that they represent the shattered remains of large bodies or that they represent the nuclei of such bodies subsequently destroyed by rusting. The late O. C. Farrington made a careful study of the history of each meteorite in this region and its geographical relationship to meteorites of a similar character. In his opinion the distribution of these irons did not support the view that they represented one great swarm (*Mem. Nat. Acad. Sci.*, XIII, 11, 1915).

For the above reasons I am unable to agree with Melton and with Wylie[34] in accepting the available evidence as suggesting a common origin for many of these irons, or of any possible relationship between them and the region of Bays.

As has been pointed out above, two types of meteor craters have been discussed in the literature—gouged holes and explosion craters. The meteoritic hypothesis for the Bays is based on the gouging theory, for the explanation of the multiple rims required that one rim be pushed ahead of the penetrating mass and the other rims be splashed out to a greater distance. It has been estimated that were the peat and associated vegetable matter removed from a typical Bay the volume of the void thus created would be at least twenty-five times the volume of the material comprising the rim.[35] The gouging process does not allow for the disappearance of this material, a fact which seems to have been overlooked in the published discussion. An explosive origin as a result of meteoritic impact may be suggested which, by vaporization, would permit the removal of this material. Yet, as pointed out below, the Bays show no similarity to the several meteor craters known to be of explosive origin.*

The Bays are said to have a depth of ten to twenty-five feet, possibly greater for the larger Bays—those which are a mile or more in length. The Arizona Meteor Crater has a diameter of four-fifths of a mile, the visible crater is nearly six hundred feet deep, and the borings show that meteoritic penetration extended to nearly 1300 feet below the plain. The two types of depressions appear to be non-comparable.

It has been suggested that the meteorites which caused the Bays struck at a low angle, approaching grazing incidence. If we assume the gouging process, as did the proposers of the meteoritic theory, the maximum slant of the bodies' motion can be computed from the evidence given by the Bays. The mean eccentricity has been given as 0.336. This ratio involves both the major and minor axes of the ellipses. If the striking body causes a circular impact region on a surface normal to the

[34] C. C. Wylie, Pop. Astr., **41**, 410, 1933.
[35] F. A. Melton, *Jour. Geol.*, **42**, 99. 1934.
*The magnetometer survey of North and South Carolina by W. F. Prouty and party (*Jour. Geol.*, **43**, 200-207, 1935) is interesting, but the great distance between the anomalous regions of high magnetic γ and the Bays is not reassuring to any supposition of connection between them.

motion, the projection of this circle onto the ground at the slant i would give the observed ellipse. It follows then that if a is the semimajor axis and b the semiminor axis of the ellipse, $\sin i = b/a = (1 - e^2)^{\frac{1}{2}}$ from which we determine $i = 63$ degrees. The slanting impact would certainly not be less effective along the direction of motion of the meteorite, but would tend to increase the eccentricity of the impact-region above the expected amount. Therefore, the impact angle computed is a maximum. In comparison with the observed elliptical shapes of the Bays, we have the circular Arizona crater where the body struck at an angle of 45 degrees, and the "roughly circular" Siberian craters where the bodies struck at 66 degrees or more with the vertical.

If we neglect atmospheric retardation (as above), the least possible velocity which the striking bodies could have had is seven miles a second, the velocity of escape from the earth. Undoubtedly the velocity of impact would have been considerably more than this, and it appears to be impossible to "ease the bodies to earth" at such a small velocity that the normal explosive reaction for such bodies would not occur. The Bays, nearly one-half of which are more than a quarter of a mile in length, are, in the mean, very large in comparison with the known meteor craters—the Arizona crater has a diameter of 4,000 feet, but all the other known craters are about 600 feet or less in diameter. However, meteor craters formed by an explosion are roughly circular in shape in comparison with the decidedly elliptical shape of the Bays. We therefore conclude that the first, and most vital, assumption, namely that meteorites striking the ground at a slant will produce elliptical craters, is incorrect. Furthermore, since basins the size of the Bays could not have been formed by the gouging process typical of small meteorites, and since they are not circular like meteor craters, we conclude that the Bays are not of meteoritic origin.

One of the important characteristics of the Bays is the variation of ellipticity with size. The meteoritic theory assumed that the smaller pieces would be retarded more by the air and would therefore fall more vertically than the larger pieces, thus forming more nearly circular holes. If this suggestion were correct, we would expect to find the small Bays on one side of the region and the large Bays on the other, for the small bodies, being greatly retarded, would not travel as far as the larger masses. This segregation is not observed. Again, if this suggestion were correct, we would expect to see the result greatly magnified in the known meteoritic craters, for they, being smaller, would have been formed by even smaller bodies. There is only slight evidence for such an atmospheric effect, and it would disappear rapidly as the size and kinetic energy of the body increased. If we were to apply this suggestion to the explanation of the single oval crater at Henbury, the pre-atmospheric distribution of the bodies would have been most peculiar. At Ösel, Estonia, the single oval crater is of intermediate size and an even more improbable pre-atmospheric arrangement of the bodies would have been required. There seems to be no doubt that, as

applied to masses with sufficient energy to form large craters, the suggestion that the atmospheric retardation of the smaller bodies would be sufficient to cause them to strike at angles noticeably different from those of the larger bodies is untenable.

So far in this discussion no mention has been made of the origin of particles of the size necessary to form the many large craters. A comet head has been suggested both for the Bays and for the Arizona crater. There is some evidence that the latter crater was formed by a compact swarm of small particles, but it would be impossible to have each Bay formed by a separate group. The individual Bays must have been

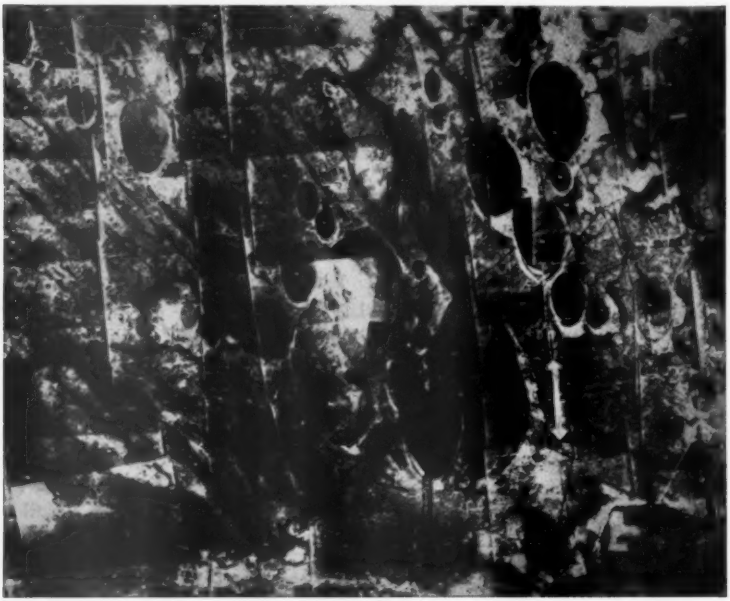


FIGURE 6
COMPOSITE AERIAL PHOTOGRAPH OF THE CAROLINA BAYS, MYRTLE BEACH ESTATES, NEAR CONWAY, SOUTH CAROLINA.
The white arrow indicates a length of one mile.
Reproduced by permission of J. D. Woodside.

formed by single particles. Therefore, it is necessary to inquire whether the nuclei of comets' heads (which certainly will contain whatever large masses might comprise the comet) are observed to have the size required for the bombardment of such a large area. Also, it is necessary to inquire whether comet heads will contain meteoroids of the size required for the formation of such large basins.

The measures of the continuous spectrum of Halley's Comet indicate

that its nucleus was about 600 miles in diameter. This is larger than the observed nuclei of nearly all comets, which usually have a diameter of 100 miles or less; occasionally no nucleus is observed. Thus it is possible to have a comet nucleus of the size required here (approximately 500 miles in diameter), but it is improbable. The best observations we have regarding the size of the particles in comet nuclei are obtained during meteor showers. To date no known meteorite can be identified as having been a member of a periodic meteor shower—the debris of a disintegrated comet. Even during the famous Leonid showers of 1833 and 1866, the Bielid showers of 1872 and 1885, and the recent Giacobinid shower in 1933, when the earth entered distinct clusters of such bodies, there were no indications of particles larger than the customary "pin head" size of meteors.* The (Tunguska) Siberian craters are smaller than those at Henbury, and there are undoubtedly less than fifty of them. The total area over which they are distributed is only a few square miles, and the swarm which they formed must have been of such a small size and low mass as to be non-comparable with that required for the Bays. Even the largest meteorites known are insignificant when compared to the bodies required by the meteoritic theory to form the Carolina Bays. Thus we must conclude that the existence of the required swarm of giant meteoroids is not probable.

In summary, we have found that the predominant shape of meteor craters is "roughly circular." From the observational evidence of the Arizona crater and the Siberian craters, the angle of impact seems to have little or no influence upon the form of the crater produced. The impact probably results in an explosion from the partial vaporization of the meteoritic material. The destructive effects and tremendous energy released by such an explosion are evidenced by the data on the Siberian craters. When the generalizations regarding the explosive process of crater formation are applied to the hypothesis of the meteoritic origin of the Carolina Bays, the following results appear:

1. The supposedly common origin of many of the meteorites found in the Southern Appalachian Mountain region cannot be accepted.
2. The proposed relationship between these irons and the Carolina Bays is extremely doubtful.
3. The assumed effects of a swarm of giant meteorites striking the earth at a considerable angle have been shown to be fallacious in two critical points.
4. The existence of the necessary swarm of giant meteoroids is unlikely.

It is, therefore, impossible to accept the theory of the meteoritic origin of the Carolina Bays.

I wish to express my appreciation to Dr. B. J. Bok and other members of the Harvard College Observatory staff who, by their comments and criticisms, have aided materially in the organization of this paper.

*The Mazapil meteorite fell during the Bielid shower in 1885, but the circumstances of its fall are such that any relationship between it and the meteor shower is very improbable.

Venus Visible at Inferior Conjunction

By H. B. CURTIS

It is commonly supposed that for a brief interval of a month or so between "evening star" and "morning star" Venus is invisible. But such is not always the case. Last summer (1935) Venus was queen of the western sky but faded rapidly during the latter part of August. Venus was at "greatest brilliancy" as an evening star August 3 and at greatest brilliancy as a morning star October 15. In about the middle of that period Venus passed the sun from east to west, being closest to the sun for the year's particular setup on September 8, when it is said to be at "inferior conjunction." While Venus near that date was on or close to the sun's hour circle, it was about 9° *south* of the sun. Hence, in an interval of a few days Venus set before the sun so it was not an evening star. Being south it rose after the sun so Venus was not a morning star. Whatever status we may define Venus to have had during this brief interval, it was nevertheless visible every day literally during the day, that is, in the day time.

Now on September 5, when Venus and the sun were on the same hour circle, the writer made many naked-eye observations of Venus from two or three hours before noon until an hour or so after noon. It was a bright dot in the sky but not nearly so bright as it was the first week of August, but nevertheless plainly visible. The sky was unusually clear. Though this sky was somewhat brightened by the proximity of the sun, still it was blue enough 9° below the sun for Venus to be visible. A neighbor of the writer also had no difficulty whatever in seeing it. It was possible by shading the sun from the eyes by the hand, to hold the eye on Venus and walk to a spot where it could be seen over the gable of a house by all who wished to look. Any pair of eyes with normal vision could easily have seen Venus that day, September 5, since the eye could be thus directed to the right spot. Seeing Venus in the day time is just a trick of "knowing where to look." It would be only fair here to add parenthetically that there are passages of Venus at inferior conjunction when Venus *is* too near the sun to be visible to the naked eye, as for instance when the nodes are so situated that there is a "transit" or a near transit. The inferior conjunction of Venus of September 8, 1935, was particularly favorable.

On September 5, through a pair of binoculars magnifying 8 times, Venus' crescent could be easily discerned while through a small telescope having a magnifying power of 35 diameters, the beautiful thin crescent with horns or cusps pointing down was a delight to behold, resembling a curiously tilted "new moon." It seemed to this observer that the cusps of the crescent extended slightly more than half way around Venus' disc while in the case of the new moon the cusps seem to

fall somewhat short of half way around. The full disc of Venus was not apparent.

On September 9, the day after Venus was at inferior conjunction, the writer saw Venus several times very distinctly through the pair of binoculars and also through the small portable telescope, but the "seeing" was not quite good enough for naked-eye observation. On the following morning, however, September 10, the "seeing" was excellent. The writer had no difficulty in finding Venus with the naked eye several times in the interval of an hour or two just before noon. Venus was then southwest of the sun and noticeably closer to the sun than it was on September 5 when both were on the same hour circle. On September 8 when Venus was in conjunction, the sky was overcast all day, but, if it had been as clear on that date as it was on September 10, the writer believes Venus would have been easily visible to the naked eye the very day of inferior conjunction.

The following discussion shows why Venus was continuously visible each day (barring clouds) through this period of near approach from evening star to morning star.

The plane of the orbit of Venus is tilted 3° 24′ to the plane of the ecliptic. That is, Venus' maximum heliocentric latitude is 3° 24′. Now it just happened that on September 9 of this year Venus' heliocentric latitude (*Nautical Almanac,* p. 168) was south by this maximum amount. The reason that Venus appeared 9° south of the sun instead of only about 3° is obvious from the following figure where the numbers denote millions of miles:

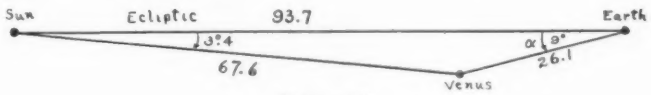


FIGURE 1*

Since the angles are small, we have:

$$\alpha/67.6 = 3.4/26.1$$
$$\text{or } \alpha = 9° \text{ (approximately).}$$

Hence Venus would appear about 9° south of the sun.

This agrees fairly well with direct readings from the *Nautical Almanac* which gives for September 5 Venus' declination as about —2°.5 and the sun's declination as about +6°.9. This shows that Venus was about 9° south of the sun. The right ascension of both the sun and Venus is given by the *Nautical Almanac* for September 5 as about $10^h\ 55^m$. Hence they were on the same hour circle on that date although not quite in conjunction. Figure 2 shows how it was possible to see Venus with the naked eye practically at inferior conjunction. The actual conjunction occurred September 8, but Venus was only slightly closer to

*Numerical values were taken from data given in the *Nautical Almanac* for 1935: pages xvi, 13, 168.

the sun on that date than it was on September 5 when they both had the same right ascension. The figure shows the southern sky along the meridian.

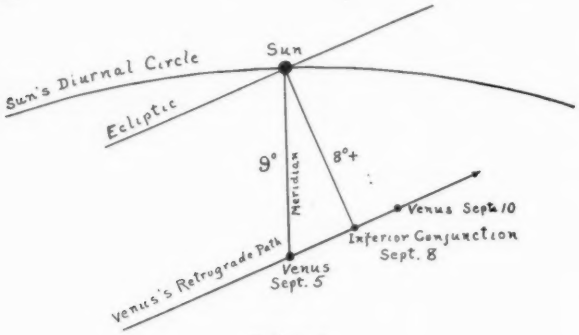


FIGURE 2

It has been a favorite pastime of the writer to point out Venus frequently in the day time to friends and acquaintances and always with enthusiastic response. But seeing Venus with the naked eye at inferior conjunction is a feat of added interest.

LAKE FOREST COLLEGE, LAKE FOREST, ILLINOIS, SEPTEMBER 20, 1935.

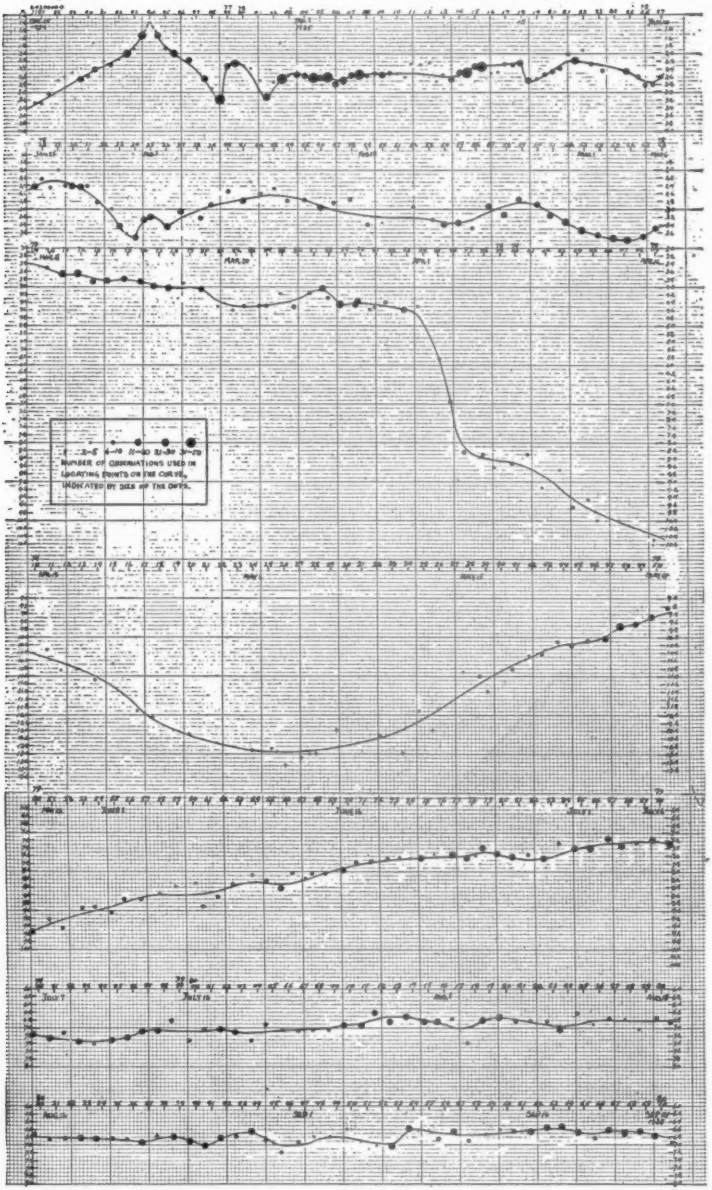
Light Curve of Nova Herculis

By HERBERT C. WILSON

The light curve of Nova Herculis ($18^h\ 04^m\ 40^s.5$, 45° 50′ 40″), shown on page 21, has been drawn by the writer from the estimates of the A.A.V.S.O. which have been published in the recent numbers of POPULAR ASTRONOMY (February to December, 1935). The number of observers, if I have counted correctly, is 141 and the number of estimates of brightness of the nova about 3420. Some of the observers recorded more than one estimate on the same night and where there seemed to be no evidence of real change I have combined two estimates in one in determining the average for the night, so as to avoid giving an observer greater weight than others.

Since the estimates on many nights were too numerous to be plotted individually and the obvious errors of many of the estimates quite large, I decided to plot only the arithmetical means for approximately each half day. After February 5 it appeared that daily means would be sufficient.

The range of the estimates by different observers at approximately the same time is surprisingly large, often a whole magnitude or more. At first I tried to determine systematic corrections for some of the observers but gave this up after finding consistent corrections of $0^M.3$ or



THE LIGHT CURVE OF NOVA HERCULIS
From observations by the A. A. V. S. O. from December 14, 1934, to September 24, 1935.

$0^M.4$ for an observer for a month or more, only to find this correction change sign for a week or two, or alternate sign and vary in value. It seemed best finally to use the uncorrected estimates, rejecting those which deviated more than $0^M.5$ from the mean of the others on the same night. In a few instances estimates $0^M.6$ off from the mean were retained where they were balanced by others $0^M.5$ off with the opposite sign.

The number of estimates thrown out because of excessive error is 150.

The average error of the estimates used, as compared with the means, ranges from $0^M.10$ to $0^M.30$, where there are enough estimates to determine the means fairly well, *i.e.* by 11 or more observers. The estimates of the more experienced observers, so far as I can recognize them from their names, usually run within $0^M.1$ or $0^M.2$ of the means.

In order to indicate to the eye of the reader something of the relative weight to be attached to the various points plotted along the curve the dots were drawn of different sizes, the largest indicating that it depends upon from 31 to 50 observations, the next largest from 21 to 30 observations, the next 11 to 20, the next 6 to 10, and the smallest dot 2 to 5 observations. Single observations are indicated by small crosses. A key to this scale of numbers is shown in the rectangle at the left of the middle of the chart.

The numbers on the right and left hand margins of the chart give the ordinary scale of brightness by magnitudes, 1.0, 1.2, 1.4, etc. The numbers at the top margin of the chart, and in the six parallel lines crossing the chart, give the last figures of the Julian dates for each day from December 15, 1934, to September 24, 1935. Ordinarily only the last two figures were written, but where a change of hundreds occurs or the change from one line to the next, the next preceding two figures were written above the last two. To give the complete Julian Date in each case requires seven figures in all, the first three being 242 for the following six years. The Julian Date for January 1, 1935, was 2427804.

For the convenience of the reader I have written underneath a few of these dates the corresponding date according to our civil calendar. The short vertical line drawn beneath each of the date numbers indicates Greenwich noon.

From the chart it will be seen that the star rose rather steadily and rapidly in brightness for seven days, from magnitude about 3.3 on December 14 to $1^M.54$ on December 21 (J.D. 93.5). It reached its maximum brightness sometime between J.D. 93.5 and 94.5 when it was again at the same magnitude 1.53. Those two points on the curve are quite well determined, by the estimates of 23 and 17 observers respectively. The maximum was probably at about 94.0 but the height of the curve is uncertain, probably between magnitudes 1.2 and 1.4. The descent during the next four days was rapid to a sharp minimum at 98.5, magnitude 3.20, followed immediately by a rapid rise to magnitude 2.25 in one day, then a slower descent to $3^M.11$ at 7801.5 and a rise the next night to $2^M.61$ (this being the average of 49 estimates by 46 observers).

During January there were only small changes until toward the end of the month, when from a broad maximum at about $2^{M}.4$, January 24 to 28, the curve drops in three days to a sharp minimum of $3^{M}.8$, followed by a secondary maximum of $3^{M}.2$ and a secondary minimum of $3^{M}.4$.

During February the changes were not very large and the curve as drawn is not sustained by sufficient observations until February 20, when a smooth wave sets in with a maximum about February 25 and minimum about March 4.

After March 8 the curve might well be drawn as a straight line, save for a poorly determined depression with a minimum about March 21, the light of the star waning gradually from $3^{M}.3$ to $4^{M}.6$.

On April 1 the brightness of the star began to fall off very rapidly, losing three and a half magnitudes in three days. The waning continued but more slowly, until about the second of May, when it reached a minimum of about $13^{M}.0$. The observations here are few but no less accurate than those made when the star was bright.

The nova was near this minimum for ten days or more, but there were signs of its recovery by the tenth of May, and during the rest of the month its rise was quite steady. It reached magnitude 10.0 on May 24 and continued to rise slowly, with only minor fluctuations, through June and July. It reached a maximum of $6^{M}.7$ about July 28 and has hovered about that brightness ever since then. There is scarcely any sign of decline according to the observations published in the December number of POPULAR ASTRONOMY, which are not all included in the chart.

Observers may be able to follow the fluctuations of this Nova for many months yet. On the other hand it may wane to invisibility in a very short time.

CARLETON COLLEGE, NOVEMBER 15, 1935.

Looking for Leonids from an Airplane

By OLIVER J. LEE

On November 12 an invitation came to me, quite unexpectedly, from one of the officers of *American Airlines*, Mr. Richard Smith, to fly as a guest of the company to New York and back to observe the Leonids, on any one of their numerous regular scheduled trips. A run of cloudy, foggy weather eased up a bit and the trip was made in the mornings of November 16 and 17. On account of prevailing cloudy weather at least east of Chicago and because of the perennial interest in the Leonids, it is thought that a somewhat detailed account of my observations may be of some interest.

Mr. and Mrs. Smith saw me off personally, at the Chicago Airport. The fourteen passenger Douglas plane took off at 1:00 A.M. Saturday, pierced the low, wet cloud layer, rose to 8000 feet and headed for De-

troit. During most of the time I knelt (quite comfortably, since the position was only one more of the numerous peculiar physical positions an astronomer has to take in the course of his work) between the seats occupied by the two pilots. Except for bands of light cirrus clouds toward the east and south, somewhat illuminated by a twenty-day moon, the sky was clear. From my position I had a view of the sky between altitudes 20° and 65° extending over fully 200° in azimuth through the windows of the pilots' compartment. Leo was in sight all the time.

The pilots, Mr. Hiram W. Sheridan and Mr. William H. Records, and I saw only three meteors on the Chicago-Detroit leg of the journey. Two of these were moderately bright Leonids. After a delay of about one hour in Detroit due to low ceiling in Buffalo we again arose through the clouds to about 7500 feet. The sky was now perfectly clear but in the flight of an hour or so to Buffalo we saw not a single meteor. Unfortunately for us, the other passengers were reclining in their chairs in various states of sleep and it did not seem fair to try to enlist them in the cause of meteoric astronomy in these early hours of the morning.

Upon leaving Buffalo the kaleidoscopic phenomena of dawn above the clouds were unfolded. I was much impressed with the azimuthal extension, fully 65°, of the middle dawn and the small height of the arc—not over 8 or 9 degrees. The colors from deep red at the horizon to faint yellow at the top were crowded together.

At 1:00 A.M. Sunday we started from Newark, New Jersey, the airport for New York, and flew in clouds and a snowstorm all the way to Buffalo. From this point we went directly to Chicago, because landing conditions were impossible at Detroit.

Maintaining an altitude of around 11,000 feet and benefitting by a tail wind we held a land velocity of more than three miles a minute. The sky was beautifully clear. Reversing my seat (with the help of the very efficient stewardess, Miss Virna Maul, R.N.) I adjusted my head almost in contact with a window in the cabin and had a good view of the whole sky from azimuth N 70 E to N 30 W and from the cloud horizon to altitude fully 70°. I could not quite see Leo over the tail of the airplane. Only three meteors were seen during the flight from Buffalo to Chicago. Two of these were moderately bright Leonids which flashed across Ursa Major. I did not stop to plot their paths because of possibly losing sight of other meteors.

Although the conditions for observing the Leonids were necessarily somewhat limited I can safely say that there were not, during the aftermidnights of November 15 and 16, any more than the normal number of group meteors which one always sees around the middle of November. Certainly there was no trace of even a mild shower. I had the impression that large numbers of very faint meteors—just within the range of visibility—were darting about. They did not show up definitely enough to include in the count. After all, the human eye and brain have to be watched for errors in the small hours of morning.

The experience was most interesting aside from the question of meteors. The bewildering array of control dials in the pilots' cabin, the marvel of flying by radio beams, the thoughtful appreciation of the crews on board and on the ground are all elements in the recollection of the trip.

The chief pilot, Mr. Sheridan, remarked "During the war we airmen were heroes. Now we have to be college professors." Certainly the broad as well as special knowledge possessed by these men of the air induces, in the layman like myself, a high respect and admiration for them.

DEARBORN OBSERVATORY, NOVEMBER 21, 1935.

Visibility of the Planets for 1936

By WILLIAM MALCOLM BROWNE

The visibility of the planets during the year 1936 is shown by the accompanying diagram. It may be used equally well in any latitude.

The path of the sun is represented by the heavy vertical line in the center of the diagram marked 0^h. The lines designated by the names of the various planets show how far east or west of the sun the planets are at any particular date. The declination of each planet is indicated at various points along its path, as it also varies throughout the year and should be considered in determining the visibility of a planet.

A particular planet may be seen at some time of night during any part of the year except when the planet is too close to the sun. When a planet is less than about an hour from the sun, it is generally too close to be visible. In general, the farther a planet is from the sun, the easier it will be to see. Also the planet will be visible for a longer portion of the night.

Since the sun is on the meridian, or reaches its maximum altitude, at about noon, a planet will be on the meridian, or reach its maximum altitude, as many hours before noon as the planet is west of the sun, or as many hours after noon as the planet is east of the sun.

When a planet is one or two hours west of the sun, it is generally possible to see it low in the eastern sky just before sunrise. The planet will appear in approximately the same part of the sky as that in which the sun will be an hour or two later.

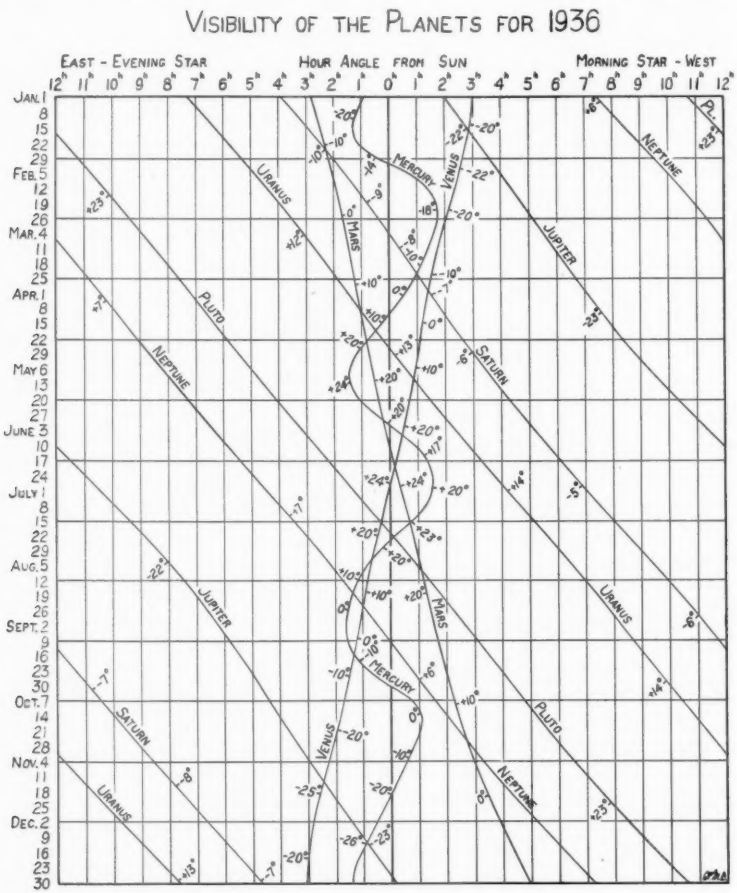
When a planet is one or two hours east of the sun, it is generally possible to see it low in the western sky just after sunset. The planet will appear in approximately the same part of the sky as that in which the sun was an hour or two earlier.

The planets Mercury and Venus are most easily seen at or near the times of their elongations. These occur when the planet is farthest east or west of the sun.

The visibility of a planet is increased if the planet's declination is

favorable. The planet's declination should be plus for best visibility in the north temperate zone, and minus for best visibility in the south temperate zone.

A planet is in conjunction with the sun when its path on the diagram intersects the 0^h line. The planets Mercury and Venus may have both



inferior and superior conjunctions. Inferior conjunction of Mercury and Venus occur when the planet crosses the 0^h line in an east to west direction, while superior conjunctions of Mercury and Venus occur when the planet crosses the 0^h line in a west to east direction. The other planets can have only superior conjunctions.

A planet is in opposition to the sun when its path on the diagram

crosses the 12^h line. Two planets are in conjunction with each other when their paths on the diagram intersect. A planet is a morning star when it is on the right of the 0^h line; it is an evening star when it is on the left of the 0^h line.

Most of the planets are easily visible to the naked eye, except when they are close to the sun. Uranus is just visible to the naked eye under favorable circumstances. Neptune is visible in a small telescope or a good pair of field glasses. Pluto can be seen only with the aid of a fairly large telescope.

WASHINGTON, D. C., DECEMBER, 1935.

Planetary Phenomena in 1936

By HERBERT C. WILSON

ECLIPSES

During 1936 there will be four eclipses, two of the sun and two of the moon. The only one of these which will be of especial interest to atronomers is the total eclipse of the sun which will occur on June 19. Some remarks concerning this one will be given later in this paper.

The following data concerning the eclipses, as well as those concerning the planets, are taken from the *American Ephemeris and Nautical Almanac* for 1936.

Note: In the tables which follow the longitudes are reckoned from Greenwich. The sign + means west for longitude and north for latitude; the sign — means east for longitude and south for latitude. G.C.T. signifies Greenwich Civil Time, the 0 hour beginning at midnight and the afternoon hours being numbered from 13 to 23.

I. A TOTAL ECLIPSE OF THE MOON, JANUARY 8, 1936.

This eclipse will be invisible at Washington; the beginning visible generally in the northeastern part of the Atlantic Ocean, Europe, eastern Africa, Madagascar, Asia, the Indian Ocean, Australia, Polynesia, the western part of the Pacific Ocean, Alaska, northwestern Canada, and the Arctic Ocean; the ending visible generally in the eastern part of the Atlantic Ocean, Europe, Asia, and Africa, the Indian Ocean, Australia, with the exception of the southeastern part, the western part of the Pacific Ocean, northwestern Alaska, and the Arctic Ocean.

Circumstances of the Eclipse:

	Greenwich Civil Time			
		d	h	m
Moon enters penumbra	January	8	15	16.9
Moon enters umbra		8	16	28.1
Total eclipse begins		8	17	57.8
Middle of the eclipse		8	18	9.5
Total eclipse ends		8	18	21.2
Moon leaves umbra		8	19	50.7
Moon leaves penumbra		8	21	1.5

Magnitude of the eclipse = 1.022 (Moon's diameter = 1.0).

II. A TOTAL ECLIPSE OF THE SUN, JUNE 19, 1936.

The partial phases of this eclipse will be visible over the most of Europe and Asia, the northern part of Africa, the north polar regions, including Greenland and Alaska, and the northwestern part of the Pacific Ocean. The path of total

eclipse starts in the Mediterranean Sea northeast of Tripoli, passes northeastward over Athens, Greece, soon after sunrise; crosses the tip of Turkey not far from Constantinople, then over the Black Sea and across the vast stretch of what used to be Russia and Siberia, touching the north tip of Manchuria (Manchukuo); then southeasterly across the peninsula north of Vladivostok; then across the Sea of Japan and the two northern tips of the island Hokkaido, Japan, ending in the Pacific Ocean about 450 miles west of the Midway Islands.

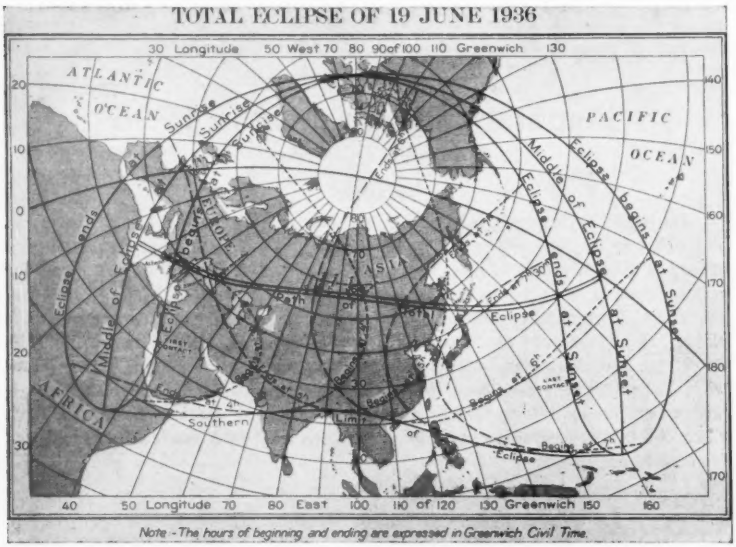

TOTAL ECLIPSE OF 19 JUNE 1936
30 Longitude 50 West 70 80 90of100 110 Greenwich 130
ATLANTIC OCEAN
PACIFIC OCEAN
AFRICA
ASIA
Sunrise
Middle of Eclipse begins at Sunset
Middle of Eclipse ends at Sunset
Eclipse ends
Eclipse begins at Sunset
Eclipse
Southern Limit of Eclipse
40 50 Longitude 70 80 East 100 110 of 120 130 Greenwich 150 160
Note - The hours of beginning and ending are expressed in Greenwich Civil Time.

FIGURE 1

The chart, Figure 1, shows the limits of the area in which the eclipse may be seen. The broken lines show where the eclipse begins at 3^h, 4^h, 5^h, and 6^h, Greenwich Civil Time, and where it ends at 5^h, 6^h, 7^h, and $7^h\,30^m$. To obtain the local standard time add 2^h, 3^h, 4^h, etc., up to 9^h for Japan, according to the standard time zone in which the observer is located at the moment of observation. If the resulting hour is more than 12 it will be an afternoon hour, so that 12 should be subtracted to obtain ordinary watch time.

Circumstances of the Eclipse:

	G.C.T. d h m	Longitude ° ′	Latitude ° ′
Eclipse begins	June 19 2 45.0	— 38 27	+22 58
Central eclipse begins	19 3 49.6	— 15 58	+33 51
Central eclipse at loc. app. noon	19 5 15.4	—101 26	+56 24
Central eclipse ends	19 6 50.5	—179 37	+25 36
Eclipse ends	19 7 55.3	—157 54	+14 32

III. A PARTIAL ECLIPSE OF THE MOON, JULY 4, 1936.

This will be invisible at Washington; the beginning visible generally in the Antarctic Ocean, the Indian Ocean, Australia, the western and southwestern parts

of the Pacific Ocean, Asia, with the exception of the extreme northern part, and the southern and eastern parts of Africa; the ending visible generally in the southeastern part of the Atlantic Ocean, Africa, with the exception of the northwestern part, eastern Europe, Asia, with the exception of the extreme northeastern part, Australia, the Antarctic Ocean, the Indian Ocean, and the southwestern and western parts of the Pacific Ocean.

Circumstances of the Eclipse:

	Greenwich Civil Time d h m
Moon enters penumbra	July 4 14 59.1
Moon enters umbra	4 16 26.7
Middle of the eclipse	4 17 25.2
Moon leaves umbra	4 18 23.7
Moon leaves penumbra	4 19 50.8

Magnitude of the eclipse = 0.272 (Moon's diameter = 1.0).

IV. An Annular Eclipse of the Sun, December 13-14, 1936.

This will be visible in Australia and neighboring islands, and over a large part of the south Pacific and Antarctic Oceans (see the chart, Figure 2). The

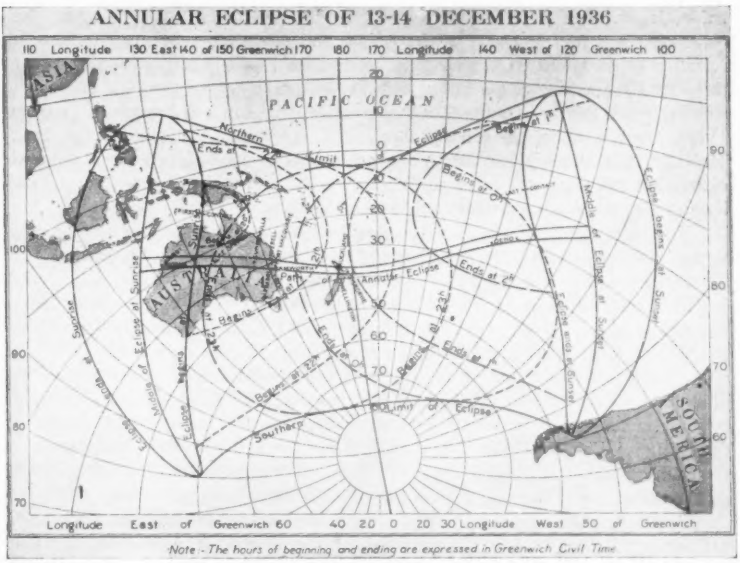

ANNULAR ECLIPSE OF 13-14 DECEMBER 1936
110 Longitude 130 East 140 of 150 Greenwich 170 180 170 Longitude 140 West of 120 Greenwich 100
ASIA
PACIFIC OCEAN
AUSTRALIA
SOUTH AMERICA
Northern Limit
Southern Limit
Limit of Annular Eclipse
Ends at 22h
Ends at 2h
Begins at 22h
Begins at 0h
Longitude East of Greenwich 60 40 20 0 20 30 Longitude West 50 of Greenwich
Note - The hours of beginning and ending are expressed in Greenwich Civil Time

Figure 2

path of annular eclipse begins on the ocean between the island of Java and the northwestern coast of Australia; crosses Australia in a southeasterly direction, passing off the eastern coast about 200 miles north of Sydney at about 9h A.M., local time; passes easterly over the northern island of New Zealand near noon, including Auckland within its limits; ending in mid-ocean at sunset without having touched any of the small islands in the Pacific during the afternoon, excepting

the little island Oeno, about 100 miles north of Pitcairn Island.

The width of the path near Auckland will be about 160 miles and the duration of the annular phase on the central line there will be $7^m\ 25^s$. Near the center of Australia the duration will be $5^m\ 36^s$; on the coast north of Sydney it will be about $6^m\ 20^s$.

Circumstances of the Eclipse:

		G.C.T. d h m	Longitude ° ′	Latitude ° ′
Eclipse begins	December	13 20 26.7	—137 24	—10 27
Central eclipse begins		13 21 34.7	—118 12	—15 21
Central eclipse at loc. app. noon		13 23 26.6	+173 1	—37 51
Central eclipse ends		14 1 20.7	+106 40	—11 14
Eclipse ends		14 2 28.6	+125 47	— 6 20

ADDITIONAL NOTES CONCERNING THE TOTAL ECLIPSE OF JUNE 19, 1936

On the chart, Figure 1, the following cities are plotted as being within the path of totality: Athens, Greece; Brusa (Bursa), outh of Istanbul (Constantinople); Krasnodar, northeast of the Black Sea; Omsk, Kainsk, Tomsk, Kansk, and Bratsk, in the southern part of Siberia (U.S.S.R.); Khabarovsk, in the southeastern part of Siberia; Koito (Wakkanai?), and Nemuro, on the island of Hokkaido, Japan.

At Athens the total part of the eclipse will occur too soon after sunrise for scientific observations of great value, but the sight will be an interesting one to those who are willing to get out at 4:35 in the morning.

At Brusa (a city of some 60,000 population) the sun will have been up about $1^h\ 20^m$. At Krasnodar the sun will be about $2^h\ 20^m$ high. According to the Rand-McNally 1931 Atlas, Krasnodar has a population of 166,000. Armavir, approximately 100 miles east of Krasnodar, appears to be nearer the central line of totality and also to be on the railway line from Moscow to Baku.

The most favorable places for observations of the total eclipse, so far as position of the sun is concerned, are those in Siberia from Omsk to Khabarovsk. At Omsk the sun will be about $2^h\ 30^m$ east from the local meridian, and at Khabarovsk it will be about 3^h west of the meridian, at the time of total eclipse. Omsk has a population of 166,400 and is on the main line of the Trans-Siberian Railway. Khabarovsk has a population of 49,000 and is also situated on the railway.

Kainsk and Kansk appear to be on the railway main line, according to the older Map of the World, published a few years ago by the National Geographic Society, but Kansk is omitted from the new map which has just been issued by the Society. Bratsk, which is the city nearest the locality where the middle of the eclipse will occur at local apparent noon, unfortunately does not appear to be on the railway, and is omitted from the new National Geographic map.

Tomsk, which is apparently on a short branch line of the main railway, has a population of about 94,700. On pp. 830-1 of the *American Ephemeris* for 1936 there is given a complete computation of the times of the eclipse for Tomsk. This gives the local times of beginning and end of totality as $10^h\ 32^m\ 51^s.6$ and $10^h\ 35^m\ 17^s.2$ in the forenoon of June 19.

The path of total eclipse is approximately 84 miles wide near the point where totality occurs at noon, the diameter of the shadow cone there being about 71 miles.

The duration of totality on the middle line near Krasnodar will be about $1^m\ 30^s$, increasing as the shadow moves eastward to about $2^m\ 16^s$ at Omsk, reaching its maximum of $2^m\ 31^s.7$ in the vicinity of Bratsk, then decreasing gradually to

about $2^m\ 10^s$ at Khabarovsk, and $1^m\ 52^s$ in the vicinity of Nemuro, Japan.

The latest National Geographic map of the world, referred to above, shows in red five airways from Moscow (Moskva) which cross the path of total eclipse. It may be that other observing stations may be made available by these, especially if large scale maps of the eclipse track should be published soon.

The through airway from Moscow to Vladivostok crosses the path of totality four times, following in general the railway.

An airway from Irkutsk down the Lena River crosses the eclipse track between Verkholensk and Ust Kutsk, approximately 50 miles south of the latter place.

The Planets

Mercury makes 4.15 circuits around the sun in a year, but, since the earth makes one circuit in the same time, with reference to the line joining sun and earth Mercury makes only 3.15 circuits (synodic revolutions) around the sun each year. Mercury begins the year as evening star, about an hour east of the sun, comes to greatest elongation, 18° 30′ east from the sun, on January 16, around which time the planet may be seen best by observers in the Southern Hemisphere.

Mercury will be at inferior conjunction, between the earth and sun, January 31; then at greatest elongation west 26° 51′ from the sun on February 26, when it will be visible in the morning an hour before sunrise. During most of March and April it will be invisible, superior conjunction occurring April 10.

In the second circuit Mercury will be at greatest elongation east, 21° 20′, on May 7; at inferior conjunction May 31; at greatest elongation west, 22° 18′, June 25; and at superior conjunction July 24.

In the third circuit greatest elongation east, 27° 05′, will occur on September 4; inferior conjunction will come on October 1; greatest elongation west, 18° 10′, on October 10; and superior conjunction on November 18. On the next circuit greatest elongation east, 19° 37′, will occur on December 29.

At the time of the total eclipse on June 19 the planet Mercury will be about 20° west and 6° south of the sun, and so should be easily seen during the time of totality.

Venus makes 1.62 circuits around the sun in a year, but only 0.62 of a circuit with reference to the earth-sun line. This year will be spent largely in the farther half of that circuit, the planet being at superior conjunction (behind the sun) June 29. It will be the bright evening star in the west during the first four months of the year, until its radiance is hidden by that of the sun; then, after emerging from the morning dawn, it will be seen as morning star in the east during the remainder of the year. Its stellar magnitude will range from —3.7 on January 1 to —3.3 in April and September and back to —3.7 on December 31.

On June 19 at the time of the total eclipse of the sun, Venus will be about 3° west of the sun and very conspicuous.

Conjunctions of the planet with the moon occur every month of the year, those most worthy of notice being:

February	20	9^h	32^m	G.C.T.	Venus	1°	17′	south	of	moon's	center
October	18	4	13	"	"	2	9	north	"	"	"
November	17	11	0	"	"	2	26	south	"	"	"

Conjunctions of Venus with Jupiter will occur on January 15 at 18^h G.C.T., Venus being then 1° 23′ north of Jupiter; and again on November 13 at 12^h, Venus being 1° 52′ south of Jupiter.

A conjunction of Venus with Saturn will occur on March 30 at 21^h G.C.T., Venus being then 0° 26′ north of Saturn.

Mars will be in conjunction with the sun on June 10 at 15^h G.C.T., and so will be in favorable position for observation only during the first and last quarters of the year. A conjunction of Mars with Saturn is noted for January 25 16^h, Mars being 0° 53′ north of Saturn. A conjunction of Mars with Uranus will occur on April 8 4^h, Mars passing 0° 25′ north of Uranus.

On June 19 Mars will be about 2° west and about 35′ north of the sun's center at the time of the total eclipse.

The course of Mars will be easterly along the ecliptic during the entire year.

Jupiter. The course of Jupiter will be in the constellations Scorpio and Sagittarius, eastward until April 10, westward until August 11, then eastward during the remainder of the year. The planet will be at quadrature, 90° west from the sun March 14, and at quadrature, 90° east from the sun, September 8. It will be at opposition to the sun on June 10 and so will be in favorable position for evening observation during the summer and autumn. It will be in conjunction with the sun on December 27.

Occultations of Jupiter by the moon will occur on October 20 and November 17, but they will be visible only in the regions of the south Indian and south Pacific Oceans respectively.

Saturn will be in conjunction with the sun on March 3 and so will be in unfavorable position for observation during the first half of the year. It will be at quadrature, 90° west from the sun, June 13; at opposition, September 12; and at quadrature, 90° east from the sun, December 8. Its course this year lies in the constellation Aquarius eastward until July 4, then westward until November 20, then eastward again.

The earth this year is very near the plane of the orbits of the seven inner satellites of Saturn, so that their orbits will appear to be practically straight lines. The rings also being turned edgewise to us will appear as a thin straight line and will probably disappear altogether for a few days about July 1. It will be very interesting to watch Saturn at this time.

Uranus will be in the constellation Aries during the year. On March 1 it will be about 11° south of the star α Arietis. It will be in best position for observation in the autumn and early winter months, being at opposition to the sun on October 31.

Neptune will be at opposition March 6 and so will be best seen during the winter and spring months. It will be at conjunction with the sun September 9. Its short course lies in the southeastern part of the constellation Leo.

Pluto can be seen only with the aid of a very large telescope. It moves very slowly in the area about midway between the star κ Geminorum and the stellar cluster in Cancer.

Planet Notes for February, 1936

By CLIFFORD E. SMITH

Note: All times, unless otherwise stated, are Central Standard Time.

The *Sun* will be moving with a northeasterly motion from the central part of Capricornus to the central part of Aquarius. Its distance from the earth will be

increasing from about 91.5 to about 92.0 million miles. The position of the sun on the first and last days of the month will be, respectively: R.A. $20^h\ 54^m$, Decl. —17° 29′; and R.A. $22^h\ 43^m$, Decl. —8° 6′.

The phenomena of the *Moon* will occur as follows:

Full Moon	Feb.	7 at	5 A.M.
Last Quarter		15 "	10 A.M.
New Moon		22 "	1 P.M.
First Quarter		29 "	3 A.M.
Apogee		11 "	12 NOON
Perigee		23 "	4 P.M.

Mercury will be near the sun in apparent position at the beginning of the month since inferior conjunction will have occurred on January 31. Toward the end of the month, however, it will be a morning object in central Carpricornus, rising about an hour and a half before the sun. Greatest elongation west will occur on February 25 at 11:00 P.M. (26° 51′ W). Its distance from the earth will increase from about 61 to 93 million miles. The corresponding change in apparent diameter will be from about 10 to about 7 seconds of arc. Conjunction with the moon will occur on February 20 at 4:00 P.M. (Mercury 1°.2 S). The position of Mercury on the last day of the month will be: R.A. $21^h\ 1^m$, Decl. —17° 34′.

Venus will be a morning object, rising about 2 hours before the sun, and moving with an apparent easterly motion from central Sagittarius to central Capricornus. Its distance from the earth on February 1 will be about 110 million miles and this distance will increase about 17 million miles during the month. The corresponding change in apparent diameter will be from about 14 to 12 seconds of arc. Conjunction with the moon will occur on February 20 at 4:00 A.M. (Venus 1°.3 S).

Mars will be an evening object in central Pisces, setting about two hours after the sun. Its distance from the earth will be about 200 million miles. Its apparent diameter will be somewhat greater than 4 seconds of arc. Conjunction with the moon will occur on February 24 at 3:00 P.M. (Mars 6°.1 S).

Jupiter will be a morning object moving with an apparent easterly motion in northern Scorpio. During the middle of the month it will rise about 4 hours before the sun. Its distance during this period will be about 525 million miles, and its apparent diameter about 32 seconds of arc. Conjunction with the moon will occur on February 17 at 9:00 A.M. (Jupiter 2°.5 N).

Saturn will be too near the sun in apparent position to be of interest during this period. Conjunction with the sun will occur on March 3. Saturn will be in central Aquarius. Conjunction with the moon will occur on February 23 at 7:00 A.M. (Saturn 6°.8 S).

Uranus will be an evening object moving with an apparent easterly motion in southwestern Aries. During the middle of the month it will set about four hours after the sun. Its distance from the earth will be about 1880 million miles, and its apparent diameter will be about 3.4 seconds of arc. On February 26 at 3:00 P.M. it will be in conjunction with the moon (Uranus 5°.5 S). Its position on the 15th of the month will be R.A. $2^h\ 0^m$, Decl. +11° 45′.

Neptune will be a night object in southeastern Leo some 2° to the southeast of χ Leonis. It will be above the horizon most of the night hours since opposition will occur early in March. Its apparent motion among the stars will be retrograde.

The distance of Neptune from the earth will be about 2700 million miles. Its apparent diameter will be about 2.5 seconds of arc. Conjunction with the moon will occur on February 9 at 7:00 P.M. (Neptune 6°2 N). The position of Neptune on February 15 will be R.A. $11^h\ 10^m$, Decl. $+6°\ 30'$.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Publications. With this issue the monthly reports of the A.A.V.S.O. appear in a new form. No longer are the tabulated observations of the variables to be printed monthly in these columns. Instead, through arrangement with the Harvard Observatory, the observations will be published quarterly in the *Harvard Annals*, essentially in the same form as they have appeared since 1926 in POPULAR ASTRONOMY. In the *Annals* the A.A.V.S.O. observations will be in the same publication with similar observations made by the noted pioneer variable star observers—Argelander, Schönfeld, Schmidt, and others. Copies of the *Annals* containing the observations will be sent to the active observers. There will be no reprints of observations from POPULAR ASTRONOMY appearing after the 1935 issue.

The change in manner of publication has been made necessary by the rapid increase in observational data sent to the headquarters of the A.A.V.S.O. in recent months. Hereafter short series of variable star notes will be contributed regularly to POPULAR ASTRONOMY, but the purely observational data will appear as indicated above.

It is the intention to make these notes a report on recent facts concerning variable stars in general and in particular on the variables observed by the members of the A.A.V.S.O. Also, the monthly notes will contain interesting news items concerning the Association and its members.

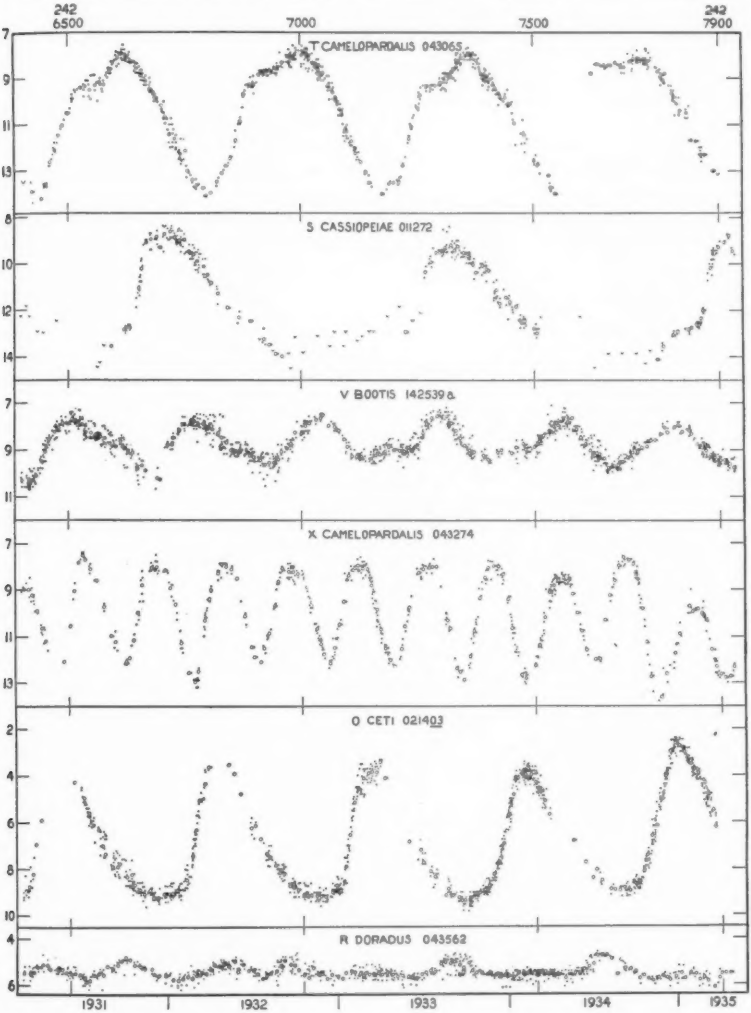
The officers and members of the Association take this occasion to express to the publishers of POPULAR ASTRONOMY their appreciation of the use of their journal, in which more than one half of a million observations have been published during the past twenty-four years. Without such help, especially during the formative years of the Association, its success would scarcely have been possible.

It is hoped that these notes will meet the desire frequently expressed by the variable star observers and others for current reports concerning variable stars and their observations.

Novae. Practically a year has elapsed since the discovery of Nova Herculis, during which time nearly 11,000 observations have been reported in various publications. Like its prototype, Nova Aurigae of 1891, it is gradually decreasing in light and is now approximately equal to the 7.4 comparison star just north of it. The strong blue-green color which Nova Herculis now presents makes it difficult to observe with the accuracy usually expected, especially with telescopes of widely different apertures. The greenish tint is probably due, in part at least, to the presence of the nebular lines in the spectrum of the nebulosity surrounding the Nova.

The sudden and second outburst of RS Ophiuchi, which was observed inde-

pendently by Loreta and Peltier in 1933, and which attained the fourth magnitude, is still fresh in the minds of many observers. Unlike most other novae, it decreased in less than three months to the magnitude it had before the second outburst and remained above the eighth magnitude for only three weeks. Instead of



stopping, in its descent to minimum, at the eleventh magnitude (the magnitude it had maintained for many years before August, 1933) the star continued to fade to slightly below the twelfth magnitude, which was reached early in 1934. Since

then, the light has gradually increased, with more or less marked fluctuations until, in November, 1935, it had reached magnitude 10.7.

T Pyxidis, the other well-known nova of this type, with three observed maxima to its credit in the past forty years, is still fainter than the thirteenth magnitude and should be carefully observed in order to detect promptly another outburst, if such should occur. A nova of this type should be classed among "recurring novae" to distinguish it from those for which so far only a single maximum has been observed. The type is particularly noted for the rapidity of both the rise and fall, only a few months instead of years being required for a return to normal brightness. The fact that the observed spectral changes during maximum so closely resemble spectral changes of the typical nova at the same phase warrants the classification of RS Ophiuchi as a nova rather than as a variable star in the ordinary meaning of the word.

Nova Pictoris, discovered in 1925, has, during the past five years, decreased only about a magnitude, from 8.2 in January, 1930, to 9.0 in October, 1935. The fluctuations in brightness have not been so frequent or so marked as those found in other declining novae.

Light Curves. A plate is printed herewith showing in detail the observations made on six selected variables under observation by the A.A.V.S.O. They present a variety of forms, large and small range, as well as short and long period. Individual observations are indicated by dots, ten-day means by circles. The observations were made during the years 1931-1935 and are typical of several hundred other stars now under observation. The curve of o Ceti, otherwise known as "Mira," is one of those shown: it was the first star to be recognized as variable (by Fabricius in 1596) and is now again at maximum.

New Observers. Messrs. Mark Howarth, of Newcastle, N. S. W., Australia, George Herbig, of Los Angeles, California, and John Luczka, of Milwaukee, Wisconsin, have joined the ranks of active observers. Students in astronomy have also been coöperating with our regular observers in making observations: Misses Mary Barnes and Jean Sanford under the guidance of Professor Alice H. Farnsworth, at Mount Holyoke College, and Messrs. Bradbury, Dennison, Francis, Hildner, and Ruth, working with Mr. Walter H. Haas, at Mount Union College.

John H. Skaggs. The Association lost by death on November 5 one of its members, Mr. John H. Skaggs, of Oakland, California. He joined the A.A.V.S.O. as an active member in 1922, observing regularly for many years with his 5-inch refractor, housed in an observatory of his own construction. The lower part of this observatory served as his print shop, and we have many evidences of his printing, particularly his annual Julian Day Calendar—issued from 1924 to 1933, inclusive—and *Variable Comments*, printed at his own suggestion, as a medium of information primarily for A.A.V.S.O. members. Mr. Skaggs was made a Patron of the Association in 1927 in recognition of his generous contributions of printed matter, which were of great value to the Association. He was not only an ardent amateur astronomer and successful printer, but an accomplished musician and an authority on California flora. Although he was never able to be present at our meetings, the memory of Mr. Skaggs will remain for a long time in the thoughts and activities of our Association.

December 12, 1935.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The Orionids, if we may judge from reports received here, were not very extensively observed. The maximum fell on the day when the moon was at last quarter and only two hours from the radiant; hence moonlight most seriously interfered, especially for observers in or near cities. As many of our most active members now report to the regional directors, who much later send these reports to headquarters, we do not have records of all the work done in October. The accompanying table lists the data at hand. We are particularly glad to have a full series of timed counts made in Hawaii and sent to us through Miss Louise M. Larrabee, for some years an active member of the A.M.S. We congratulate her on having been able to interest so many young persons, all members of the "Hui Hoku" (Star Society) of McKinley High School. As meteor work is now being actively carried on in Japan, it is of special importance to have observers in Hawaii, in an intermediate longitude. The observations made in the eastern United States (Adamson, Anderson, and Smith) indicate that there were few bright meteors on the Orionid nights. However, there is a report from the British *S.S. Albertolite,* for October 23-24, from midnight to 16 hours, when in about long. 124° W, lat. 40° N. Second Officer H. H. Rankin mentions 10 meteors seen in a casual watch, four being brilliant yellow ones. These had similar characteristics and left a trail of sparks, but no data are given by which we can determine whether they were Orionids.

ORIONIDS

Observer and Station	1935 Oct.	Began EST	Ended EST	Total	Met.	F.	Rate	Cr.R.
G. H. Adams, Tecumseh, Mich.	19-20	12:00	14:15	135	8	1.0	3.6	3.6
R. Anderson, Chicago, Ill.	18-19	15:00	18:10	190	26	1.0	8.2	8.2
F. W. Smith, Glenolden, Pa.	4- 5	16:00	17:00	60	6	1.0	6.0	6.0
	18-19	12:40	13:40	60	5[1]	0.6	5.0	8.3
	19-20	10:50	11:50	60	5[1]	0.6	5.0	8.3
	25-26	11:00	12:30	90	6[1]	1.0	4.0	4.0
G. B. Skinner, Brockton, Mass.	18-19	10:00	11:30	90	13[2]	...	8.7	...
		12:00	14:30	150	15[2]	...	6.0	...
	19-20	10:00	12:50	150	33[2]	...	13.2	...
	20-21	8:00	9:00	60	14[4]	...	...	...
		9:30	11:00	90	20	1.0	13.3	13.3
J. L. Black, Columbus, Ohio	18-19	15:50	16:50	60	5[5]	...	5.0	...
	19-20	10:56	12:56	120	4[5]	...	2.0	...
HONOLULU GROUP:								
Miss L. M. Larrabee	20-21	12:35	14:35	120	40[3]		20.0	
Fred Morimoto	16-17	12:00	13:00	60	13		13.0	
Edward Lum	18-19	11:00	12:00	60	13		13.0	

[1] Three Orionids. [2] Clear, but view restricted. [3] Partly cloudy for first hour, clear for last hour; view restricted. [4] Two observers. [5] View restricted; observations from window.

Observer and Station	1935 Oct.	Began EST	Ended EST	Total	Met.	F.	Rate	Cr.R.
Asayo Yamasaki	18-19	11:30	13:30	120	36		18.0	
	19-20	12:00	14:20	140	67		28.7	
Estelle Young	19-20	11:55	12:25	30	11		22.0	
Mrs. K. Yamasaki	19-20	12:00	14:20	140	74		31.7	
Donald Nakashima	19-20	12:00	15:00	180	50		16.7	
Mae Asahina	20-21	13:00	14:00	60	20		20.0	
Richard Fukumoto	19-20	12:00	14:00	120	58		29.0	
Tadashi Ohta	16-17	12:00	13:00	60	15		15.0	
Clarence Wong	19-20	15:20	16:20	60	33		33.0	
James Chung	19-20	13:57	17:10	178	74		24.9	
	20-21	12:32	14:06	90	31		20.7	

For the Leonids, extensive observations planned for November 15-16 and 16-17 by A.M.S. members all over the country were apparently wholly ruined by a cloud-blanket of unusual size which covered nearly all the United States and parts of Canada. To date, although we have had numerous negative reports, of clouds, not one single report of observations on the nights of probable maximum has been received. This breaks all records—in the wrong direction. Nor have I seen reports as yet from other countries.

The skies finally cleared in Upper Darby for the night of November 18-19. Casual watch was kept by several of us, and a complete hour's watch was made by B. S. Whitney from 15:25 to 16:25 (sky clear, factor 0.6). He plotted 7 meteors, 4 or 5 of which were Leonids. Earlier on that night, at 14:29, he and C. H. Cleminshaw observed a meteor in the far south which left a 90-second train. A duplicate observation of this would be most valuable.

These late observations prove that there were some Leonids still appearing on the second and third nights after probable maximum. On those probable dates there was general disappointment, as several rather unusual types of observation had been planned for a possibly fine shower. For 1936 and subsequent years, we can expect nothing better than a quick diminishing of the hourly rate of Leonids, until by 1940 they will have fallen far below the Perseids, Geminids, and Orionids in interest. I have personally been able to see some Leonids, however, at all returns since 1898 whenever the skies permitted. For example, the corrected Leonid rate was found in the years mentioned as follows: 1903, 50; 1904, 16; 1906, 13; 1909, 5. The 1909 figure is probably about a minimum. It may be noted that 1936 is 33 years after 1903, when Leonids were still about as numerous as the Perseids on August 11-12. To that extent a shower may be expected this coming year, and A.M.S. members will of course observe it as fully as possible.

Two interesting publications by Professor K. Pokrovsky and G. Schaïne, of the Perm Observatory, U.S.S.R., have only recently been received, though they appeared in 1918 and 1919, respectively.[1] As it is probable that few if any of our members have seen these papers, some comments will be made upon the first, "Radiants des Geminides, des Orionides, des γ et δ Aquarides." The authors make a complete study of these streams based upon 800 Italian and 636 Austrian observations in the years 1868-1874. From this study some conclusions are reached for each stream, among the more interesting being that the Geminids and δ Aquar-

[1] Radiants des Geminides, des Orionides, des γ et δ Aquarides, Prof. K. Pokrovsky et G. Schaïne, Perm, 1918. Les Radiants Cométaires et la Connexion entre les Comètes et les Courants Météoriques, Professor K. Pokrovsky et G. Schaïne, Perm, 1919.

ids have radiants that show a daily shift, while such shift remains unproved for the other two streams but possibly exists.

I have examined the plan and particularly the data on the radiants as published and feel at once that a caution, perhaps mildly expressed by the authors, should have been more emphasized. The enormous "radiation areas" are in my opinion due to nothing but errors of observation, accentuated by the inclusion for each night of the work of numerous men, many of the observers being unskilled. Hence any results based upon such data must be uncertain. It speaks well for the skill and patience of the authors that they derived something good from data so unhomogeneous. Indeed, the publication is well worthy of study as an example of how such data may be combined into something useful. Nevertheless, any single trained observer could make observations which would yield better results. From personal experience, I know that of the four streams studied, only one has a large radiant area—the δ Aquarids. In fact, one of the most obvious tests of an observer's skill in plotting is the size of his "radiant area" for the other three streams. It is a fallacy of long standing that one can at once learn to plot meteors accurately although years are required to gain skill as an observer at the telescope. In my opinion meteor observing is, if anything, the more difficult of the two.

Flower Observatory of the University of Pennsylvania,
Upper Darby, Pennsylvania, 1935 December 2.

The Accuracy of Estimated Meteor Durations

By BEMROSE BOYD

The determination of velocities is, perhaps, the most important problem of meteoric astronomy which remains largely unsolved at the present time. There are three general methods of attack: (1) experimental measurement as by means of a rocking mirror or a camera equipped with a rotating sector; (2) estimation or reproduction of the duration; and (3) statistical application of observations of variation of number, altitude of end point, or some other observable quantity to theoretically derived relations between these quantities and the velocity. The second of these methods is the one commonly used in ordinary observation.

The Apparatus

In order to provide an artificial meteor of accurately timed duration for the purpose of testing the accuracy of estimates as well as apparatus for measuring meteor velocities, a device has been constructed consisting essentially of a small electric bulb mounted on a moving belt and the auxiliary equipment necessary to vary the speed of the belt, to turn the bulb on and off at the proper points, and to record the duration of illumination. Current is led to the bulb through brushes bearing on flexible conducting strips fastened to the belt. Quick acting trigger switches with mercury contacts were designed and built to make and break the circuit to the bulb. These are operated automatically by a pin carried on the belt and projecting beyond its edge. This pin slides in a small metal tube so as to project either on one side of the belt or the other. It can be transferred from one side to the other while the belt is in motion by means of metal-faced wedges which can be moved up to the edge of the belt from either side. Thus the automatic switches may be caused to operate at will after the motor has been started and the belt has attained a constant speed. The distance between switches can be adjusted to any value up to ten feet. The actual duration of the electric current is record-

ed by an impulse counter connected in the circuit with the bulb and operating on 60-cycle alternating current. The present equipment affords a range of durations from 0.38 sec. to 1.80 sec. with a path length of 6 feet which subtends an angle of approximately 30° at the observer's eye.

Determination of Correction

The correction to be applied to the measured durations of current to give the true durations of visibility was evaluated experimentally for two observers. The points along the belt where the bulb first became appreciably illuminated and where the illumination ceased were determined by sighting through a cardboard tube fitted with a pinhole sight and cross threads. The distances from these points to the switches, together with the belt speed obtained from the duration of current and distance between switches, allow the time lag at both ends to be determined. These measurements give the times required for the filament to heat to incandescence and to cool off. Their difference is the desired correction. The switches were constructed as nearly alike as possible so that their action times should be the same. The adopted corrections for the two observers were +0.027 sec. and —0.088 sec. The measured time lags did not vary appreciably with the voltage across the bulb filament until this voltage was reduced from the normal value of 6.3 volts to less than four volts. From a theoretical consideration of the shape of the curves of increasing and decreasing temperature, the positive correction means that the threshold level of illumination was less than half of the full illumination representing equilibrium between the supply of energy by the electric current and loss by radiation. If exactly half of the full illumination represented the limit of noticeability, the times taken for the filament to reach this temperature and to cool off would be equal and the correction would be zero. At still higher levels of illumination the correction should be negative. The difference between the corrections found for the two observers probably represents an individual difference in the level of illumination forming the limit of noticeability. Since this correction was not evaluated for each observer, it has not been applied to the measurements discussed herein.

Experimental Procedure and Results

Eleven observers were used in the investigation. All were either college students or from homes with a background of college training. Some of the measurements were taken with the light stationary and operated by a key instead of by the automatic switches. Some durations were estimated and some were reproduced with a key similar to the operating key. For five of the eleven observers, under-estimated intervals predominated. One observer quite consistently overestimated slightly. The remaining five made about as many errors in one direction as in the other. From a separate analysis of the intervals greater and less than one second, it appears that the error of reproduced intervals normally increases as the interval is increased, but in a smaller ratio so that the percentage error decreases slightly.

Reproducing the interval instead of merely estimating it reduces the average error from 0.36 sec. to 0.20 sec. representing a reduction of 44%. For different observers the average error of reproduced intervals ranged in absolute value from 14% to 49% of the average duration. By a comparison of results with the light moving and stationary, an effect of motion is indicated but not definitely established, the measurements with the moving light being slightly more accurate. A qualitative knowledge of this effect would be necessary in correlating measure-

ments of angular velocity using the artificial meteor with experiments on durations performed with a stationary light. In experiments on two observers a five-minute delay between the observation and the reproduction of the interval increased the error 31% and 36%.

Investigation of Auditory Stimuli

The impulse counter used in measuring the durations makes a buzzing sound when operating. Since it was not convenient to eliminate this sound entirely, an attempt was made to learn what effect it might have on the reproduced intervals. For this purpose a buzzer adjusted to produce the same pitch as the sound from the impulse counter was used to mask the latter sound. For all observers but one, the errors were larger when the sound, accompanying the interval and its reproduction, was masked—the average decrease in accuracy being about 0.1 sec. In one case the error was slightly greater without the buzzer. For most people it is to be expected that an auditory cue, obtained either consciously or subconsciously, should aid in accurate reproduction of the time interval although this might depend on whether the person's imagery is dominantly auditory. A short series of measurements in which the buzzer was used to mask the sound of the impulse counter during the interval but not during its reproduction yields errors of 0.37 sec. and 0.28 sec. for the two observers. These values are greater than the errors of the same two observers either with or without the buzzer on both the original and the reproduced intervals. It is evident that the situation during the reproduction should be as nearly as possible like that during the observed duration. This series also affords striking confirmation of the psychological fact that "filled" and "empty" time intervals are estimated differently,[1] since all but 8 out of 60 durations were underestimated.

In this and other work[2] observers ranging in age from 9 to 45 years have been used. No age difference has been found although this point was not specifically investigated. There is evidence that, as might be expected, the observer's general physical condition affects the accuracy of his time estimation. A study of this kind is essentially a psychological problem but its results are applicable to the interpretation of data concerning meteor velocities.

Program for Future Research

It may not be inappropriate to present here a suggested general outline for future research. Additional work with the artificial meteor on reproduced durations would be of value, both to check and to extend the information obtained thus far. In addition to this, the artificial meteor could be used to test and measure the accuracy of velocity apparatus employing rocking or rotating mirrors and, perhaps, photographic equipment. The artificial meteor overcomes the two main difficulties in this kind of work: the infrequency of bright meteors, and the observer's inability to anticipate their appearance. Experiments should lead to the development of apparatus either visual or photographic capable of accurately measuring the velocity of individual meteors of, let us say, third magnitude. Such a device should first be applied to the observation of the Leonid meteors or some other shower for which the orbit is quite accurately known. The difference between the measured velocity and that determined by the elements of the orbit may be taken as a correction for the change of velocity within the atmosphere. With this correction known, observation of the Perseid meteors should allow the period

[1] Sturt, *The Psychology of Time*, Chapters V and VI.
[2] *The Determination of Fireball Durations, P.A.*, **43**, 600, 1935.

and orbit of that shower to be more accurately determined. Finally, observation of sporadic meteors would answer the outstanding question of their origin, whether solar or cosmic.

This work has been supported in part by a grant from the J. Lawrence Smith fund of the National Academy of Sciences, and in part by the Graduate College of the University of Iowa.

University of Iowa, December 7, 1935.

The Detonating Meteor of December 8, 1930

By LLOYD R. WYLIE

On December 8, 1930, at 5:00 P.M., 90th meridian time, one of the most widely observed meteors in recent years was seen. It fell soon after sundown and although the sky was clear in the surrounding area no stars were yet visible. It ranks therefore as a daylight meteor.

When the meteor fell, the Midwest Meteor Association did not have trained workers coöperating in central and southern Illinois. A field trip by a trained man could not well be arranged, and so the older method of requesting letters from observers was resorted to. More than a score of newspapers in the region published requests that those who saw the meteor write the Midwest Meteor Association, Iowa City, Iowa, and more than 250 letters were received from people in eight different states. The states were Arkansas, Illinois, Indiana, Iowa, Kentucky, Mississippi, Missouri, and Tennessee.

When first seen the meteor looked like a bright ball of fire sailing through the sky. It soon burst, and became two balls of fire, with sparks streaming from them, and then went out. Many of the writers of the letters compared the two balls of fire to the lights of an airplane while others thought it looked like a sky rocket in reverse.

The Bursting Point

For a good location of the bursting point we are indebted to Mr. Everett Moore, a farmer living 14 miles southwest of Vandalia, Illinois. Some years ago Mr. Moore saw the collection of meteorites at the University of Iowa, and he has since then been keenly interested in astronomy. Mr. Moore circled the end point for us, interviewing observers. This work indicated that the meteor burst over a point 16 miles south and 8 miles west of Vandalia, Illinois. This is longitude 89° 13′ West and latitude 38° 43′ North. It is in splendid agreement with "key letters" giving the point of bursting as due south or due north, or due east. Thus, it is almost due south of Atlanta, Illinois, and Mulberry Grove, Illinois. It is very nearly due east of Highland, Illinois. It is almost due north of Carbondale, Illinois.

The point of bursting is over a swampy, wooded region where two large creeks run close together. It is near their junction point and close to the Kaskaskia river. This is a poor place to search for meteorites and none have been found from this meteor.

Height of Bursting

The height of bursting is usually determined from measures of the apparent altitude made by trained persons who interview the observers on the spot where the meteor was seen. As no trained persons made interviews on this meteor in central or southern Illinois, this method could not be used. Plots of the path among the stars were used for the meteor of January 2, 1927, and for other meteors, but no stars were visible at the time this meteor fell. Others have attempted to use the estimated time interval from seeing the meteor to hearing the detonations. This estimate may well be in error by 50%, however, and an error of 50%

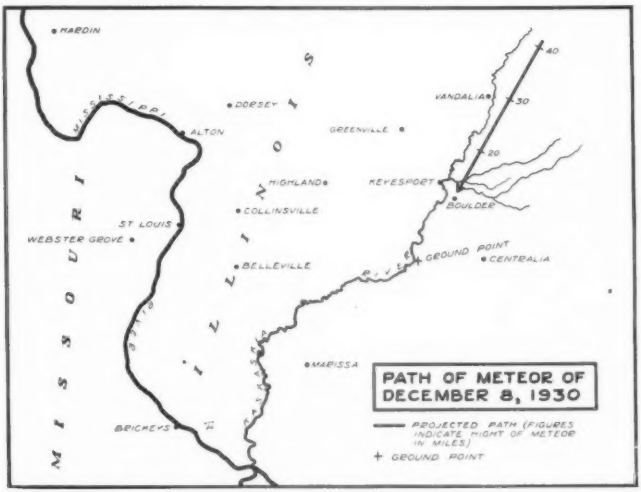
in the time interval would change the resulting height of bursting by more than 100%.

The great number of reports on this meteor make possible another method of approach. Using only those reports from observers in the open country, we find that the nearer observers report that the meteor "went out high in the air." At a little greater distance it "went out close to the ground." Then it "hit the ground," and at still greater distances it "went below the horizon." There are two reports that it "hit the ground." These are from near Erie and near Hillsdale, both in Illinois and both about 207 miles from the bursting point. The one report that it "went out close to the ground" is from near Monmouth, Illinois, about 170 miles from the bursting point.

From these reports we adopted the height of bursting as 12 miles. This places bursting 1½° above the true horizon for Erie and Hillsdale, and 3° above for Monmouth. The natural horizon in ordinary open country is above the true, unless one is on a hill, so these altitudes satisfy the reports of hitting the ground and going out close to the ground. The adopted height of 12 miles also agrees well with the statements made in letters from closer to the end point, but these statements can be considered only as very general checks. It also agrees well with the interval from seeing the meteor to hearing the detonations, as reported, as will be shown later.

The Radiant

For the determination of the radiant it is necessary to have the angle that the path of the meteor makes with the horizon as seen from each station. Few of the letters received gave this information directly, but many of the writers drew dia-



grams showing the path of the meteor. From these the angles could be obtained. Such diagrams came from Harrisburg, Carbondale, Bloomington, Colona, and Monmouth, all in Illinois; and from St. Louis and Webster Grove in Missouri; and from Fort Madison, Burlington, Danville, Mt. Sterling, and Iowa City, in Iowa. The resulting solution for the radiant as seen from the bursting point was altitude 41° 58′ and azimuth 212° 6′ from the south point. This position for the radiant yields a path that is in agreement with the statements made in the letters. For towns reporting the meteor as passing north of overhead it passes north and

for towns reporting it as passing south of overhead it passes south. Marissa, Illinois, and Brickeys, Missouri, lie nearly on the path prolonged. Hence, for both of these towns the meteor was coming nearly head-on. Both towns reported that the meteor looked like a headlight bearing down on them.

The Ground Point

The position of the radiant as seen from the bursting point yields as the ground point position latitude 38° 34′ North, longitude 89° 21′ West, a point about 12 miles due west of Centralia, Illinois, and near Posey, Illinois. The distance from the bursting point to the ground point was found to be 17.8 miles, and the projected distance was found to be 13.2 miles. The position of the radiant as seen from the ground point was found to be altitude 41° 46′, azimuth 212° 1′ (uncorrected). Corrected for zenith attraction and diurnal aberration and reduced to right ascension and declination this corresponds to right ascension 77° 40′, declination +62° 48′. This is a point in the inconspicuous constellation Camelopardalis.

Point of Noticeable Illumination

The point where the meteor reached brightness such as to attract attention was determined from the reports in the letters where the writer distinguished between first appearance and the point of bursting. Most of the letters, of course, gave only the general direction of the whole occurrence. However, reports from Alton, Dorsey, McLean, Atlanta, Cowden, and Carbondale give the direction of beginning. This point was determined as over latitude 39° 7′ North, and longitude 88° 54′ West. The meteor was 41 miles high at that point and it traveled 43.5 miles from there to the bursting point. The projected distance was 32.3 miles. This point of beginning is in agreement with all the information in all the letters.

Velocity

There were several estimates of the duration of the meteor from first seen to bursting. Estimates ranged from 1.5 to 15 seconds. The two longest estimates were discarded as being obviously in error. A straight average of the others gave 4.25 seconds as the interval of time from first seen to bursting. Since the meteor traveled 43.5 miles in this time the resulting observed velocity is 10.24 miles per second. This gives for the geocentric velocity 7.55 miles per second, and for the heliocentric velocity 19.4 miles per second. This would indicate that the meteor was a permanent member of the solar system, and that the major axis of its orbit was only a little greater than the major axis of the earth's orbit.

The value 19.4 miles per second for the heliocentric velocity is quite low, and too much reliance must not be placed on it. The study of Mr. Bemrose Boyd,[1] graduate assistant in astronomy at the University of Iowa, indicates that the best method of obtaining the duration is reenactment of the scene that occurred when the meteor was falling. For this meteor nothing was available save the guesses on the duration, some being reported a month after the meteor fell. Mr. Boyd also states, in a paper appearing elsewhere in this issue of Popular Astronomy, that the age of the person making the estimate has little influence on its accuracy. For this reason no estimates were discarded because of the youth of the observer, nor were greater weights assigned to the estimates of the more mature.

If we assume parabolic velocity, 26.2 miles per second, for the meteor before its fall, the resulting apparent velocity is found to be about 21 miles per second, or more than double that obtained. This in turn means that if the meteor had

[1] *The Determination of Fireball Durations,* Popular Astronomy, **43**, 600, 1935.

parabolic velocity, or more, the true duration must have been less than half the average of the estimates. Mr. Boyd's experiments make this appear quite improbable. Further, very many letters received from well educated people comment on how slowly the meteor moved. The writer feels, therefore, that we are justified in concluding that the meteor was a permanent member of the solar system before its fall.

Brightness

There were numerous comments on the brightness of the meteor, but little on which to make a definite comparison with, for example, the light of the full moon. It was still daylight when the meteor fell, and it did not light up the landscape enough to cause people to look up. From the fact that it was so widely observed, however, one may safely conclude that it was at least as bright, if not brighter than, the full moon.

Detonations

Detonations were reported by observers within a few miles of the end point, but it appears they attracted no attention at a distance as great as 25 miles. Mr. Everett Moore gave the only usable estimate on the interval from appearance of the meteor to detonations. His estimate was 60 seconds. The computed interval using the adopted values for position and height of bursting, and a speed of 1000 feet per second for sound, is 72 seconds. The agreement is good.

Acknowledgment

The author wishes to express his appreciation of the coöperation given by the editors of various newpapers who so generously aided in the collection of the letters. Thanks are also due to Prof. C. C. Wylie of the University of Iowa, for placing the material at the author's disposal, and to Mr. Bemrose Boyd, of the same institution, for checking the calculations.

Summary

Time of Fall, C.S.T., December 8, 1930,	5:00 P.M.
Longitude of end point	89° 13′
Latitude of end point	38° 43′
Height of end point	12 miles
Longitude of appearance	88° 54′
Latitude of appearance	39° 7′
Height of appearance	41 miles
Length of path	43.5 miles
Projected length	32.3 miles
Apparent velocity	10.2 miles
Heliocentric velocity	19.4 miles
Azimuth of radiant from south	212° 6′
Altitude of radiant	41° 58′
R. A. corrected radiant	77° 40′
Decl. corrected radiant	+62° 48′

Eastern Illinois State Teachers College,
Charleston, Illinois, December 10, 1935.

Contributions from the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD, President, *and* H. H. NININGER, Secretary

Air Pilots and "Meteor Hazards"

By H. H. Nininger

Press reports lead us to believe that air pilots are subject to a rather serious hazard because of meteors. Recently the newspapers carried a startling account of how a resourceful pilot battled a shower of meteors and by an ingenious series

of dips and swerves averted what would have proved to be a major disaster had the plane been piloted by a less dexterous hand. The culmination of this amazing feat of aërial acrobatics was a plunge for safety into a canyon. Thus, by the preservation of eleven lives and the valuable aircraft, a new name was added to the already long list of aërial heroes! Only a few months ago, another keen-witted pilot saved himself and his precious cargo of mail by dipping the right wing of his plane to avoid one of those dreadful blazing projectiles in Nebraska. In March, two years ago, two pilots in the southwest related their hair-raising experiences as they found themselves facing an aërial inferno; but fortunately both of them were spared. A third pilot, more self-possessed, regarded the scene as the treat of a lifetime. Perched at the controls, he beheld the most thrilling spectacle of his experience, a blazing meteorite below him! Imagine the distinction one would feel, sitting in the grandstand, as it were, and looking down upon the marvelous spectacle of a descending meteor! A pilot near Cheyenne, Wyoming, a few years ago also narrowly escaped an encounter with one of these pestiferous fiery projectiles which threatened to side-swipe him from the left. He "ducked," however, and the missile sailed by, leaving him unharmed.

From the standpoint of one who devotes a considerable part of his time to the survey of meteoric and meteoritic falls, the experiences of these pilots are a bit humorous. In the first place, there are about two thousand automobiles on the highways and streets of this nation to every airplane that is being flown. Certainly all of the meteorites that reach the lower atmosphere where these pilots fly, reach the ground also, and yet we have not a single authentic instance of an automobile's having been struck by a meteorite. One much published report of a car's alleged perforation by a meteorite, near Crawfordsville, Indiana, a few years ago, has been discredited by scientists who carefully investigated the matter. By the law of averages, we should expect at least a thousand casualties from meteorites striking automobiles to every one in aircraft.

These stories are even more incredible for other reasons. All astronomers know that meteors are limited to the upper atmosphere. With possibly two exceptions, no meteor has ever been known to approach nearer than four miles to the surface of the earth, and the vast majority of them are extinguished before they have come within ten miles of the ground. Meteorites, *i.e.* the stones or irons which burn, producing meteors, often do fall on, down to the ground. But these bodies are *invisible* after they lose their luminosity, unless one is near enough to see the black, non-luminous object. In other words, the meteor, or the light resulting from a meteorite's [meteoroid's] encounter with the earth's atmosphere is limited to the region of the stratosphere, far above any height ever reached in ordinary flying. To be more specific, the great meteor of March 24, 1933, which the pilot, referred to earlier in this article, thought he saw beneath him, was very carefully surveyed; and I can assert with complete confidence that it never reached a point lower than 17 miles above the soil of northeastern New Mexico. Our favored pilot evidently did not look at his instruments when he reached the conclusion that he was above the display. It was evidently a case of his being both literally and figuratively "up in the air"! My survey proved also that the other pilot, who thought he was about to collide with the same meteor, was slightly more than a hundred miles from it at its nearest approach! The pilot who dipped the wing of his plane in Nebraska, in February, 1934, to avoid disaster, was about 68 miles south of the line over which the dreaded missile was speeding at an elevation of approximately 20 miles; likewise, the Wyoming meteor missed the dodg-

ing airman by a safe margin of at least 20 miles!

Pilots are no less reliable in such matters than are ground observers, but the plain fact is that no one is able to judge the distance from him of a bright, dazzling light. Pilots apparently share the ignorance of the general public as to the behavior of meteorites. A hundred examples could be cited of errors comparable to that of a high-school superintendent who told me "exactly where" a meteorite had fallen in a neighboring field. From where he stood he confidently pointed it out. Fortunately, he knew the hour and minute of the fall and gave an eloquent description of the phenomenon, which sounded quite familiar to me, for the same story had been recited by observers all the way between the place where he and I were standing and the spot where the meteorite had actually been picked up, more than 350 miles away!

It is absolutely impossible for any single observer to judge the distance of a meteor. Its location can be determined only by a "cross-line" survey. To this, pilots might contribute considerable information if they would take account of their exact location and determine with their instruments the exact direction and altitude of the point where the meteor vanishes. It is important also to record the angle of descent. A pilot's observations by this method should be of more value than would the observations of an ordinary person, for the reason that the pilot has his instruments at hand, while the average individual is compelled usually to depend upon his judgment and memory. If the burning meteorite seems to reach the ground, the appearance ordinarily indicates that the meteor is so far away from the observer that even at an altitude of several miles above the earth's surface, it goes below his horizon! The direction of the point where it disappears and the angle of its descent are still, however, important facts in such a case, and should be recorded. In my several years of experience in plotting the courses of meteors to determine their point of landing, I have never yet been able to use the report of an air pilot. I believe, however, that we should be much benefited by their reports if once our needs were known and understood.

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Compiled by FREDERICK C. LEONARD *and* ROBERT W. WEBB

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Editorial Office: Department of Astronomy, University of California at Los Angeles.

Researches on Meteors in the Soviet Union

The Meteor Section of the Astronomical-Geodetical Society of the U.S.S.R. was founded in 1926 in Moscow. The following persons have taken part in the work of the Section: I. S. Astapovitsch, V. V. Fedynsky, N. A. Ivanoff, B. J.

Levin, A. B. Severny, K. P. Stanyukovitsch, and many others, among whom are professional and amateur astronomers and students of the Moscow University. The staff of the Section at present consists of thirty persons.

The meteoric showers Lyrids, Perseids, Aquarids, Orionids, Leonids, and Draconids have been observed for the nine years of the Section's work. Also observations of meteors in the equatorial zone (1926, 1931, 1933, 1934) and daily observations of sporadic meteors in the North Polar Region (1930-1933, made by Miss V. Barantseva) were carried out. Since 1932, the Section has undertaken to determine by a photographic method the height, the velocity, and the retardation of the bright meteors. These observations were made at the Astrophysical Observatory in Koutchino for two meteors (1932 and 1934, both in August). For the latter the spectrum was obtained which showed 47 emission lines.

In order to observe Perseids, Leonids, and showers of the equatorial zone, the Section has sent four expeditions to the Southern Republics of the U.S.S.R.: to the Crimea, Uzbekistan (Tashkent), and Tadjikistan (Stalinabad).

The Section has on record more than 20,000 observations. Out of these there are about 300 determinations of the meteor heights; the catalogue of the latter soon will be prepared.

At the present time the Section is able to use airplanes and balloons in order to observe meteors during bad weather.

The first determination of height of a bright meteor was made on October 23, 1935, by two observers from the plain near Moscow. Results of observations are published by the Soviet Scientific press, 15 authors having published about 40 articles. Some of these articles which deserve special attention are devoted to the question of the Perseid shower, results of meteor photography, and some theoretical problems. The problems of errors of the visual observations of meteors were considered, artificial meteors were studied, the method of determination of heights from the one-side and radiants was discussed, Bessel's classic theory for the coordination of the corresponding observations as applied to photographic investigation was modified, and the frequency curve of the meteor heights was considered from the statistical point of view.

In connection with the problems of the upper atmosphere special attention was given to the physical phenomena occurring during the flight of the meteor, in particular the ionization phenomena which attend the meteor's flight. At the same time such questions as determination of mass, color, and temperature of meteors, retardation as a function of the height, etc., were discussed and worked out. The Section is connected with a number of U.S.S.R. astronomical institutes, especially those situated in Moscow, as Sternberg Astronomical State Institute and Meteoric Section of the Lomonossoff Institute, Academy of Sciences of the U.S.S.R.

The Section's address is as follows: Mr. K. P. Stanyukovitsch, Planetarium, Sadovo-Kudrinskaya 5, Moscow 1, U.S.S.R.

Moscow, November, 1935.

Comet Notes

By G. VAN BIESBROECK

As the year draws to a close no known comets are visible in ordinary telescopes. However, three faint ones are in reach of the more powerful instruments. Of these three the least difficult is Periodic Comet 1927 III (Comas Solá) which remains about $13^{M}.5$ and still shows a faint tail opposite to the direction of the

sun (December 21). It follows very closely the ephemeris given on p. 654 (December, 1935), the continuation of which is computed as follows by Miss Vinter Hansen (Circ. 565 of Copenhagen):

1936 0^h U.T.		α h m	δ ° ′
Jan.	1	12 15.9	+17 47
	5	20.6	17 51
	9	24.8	17 57
	13	28.4	18 7
	17	31.5	18 19
	21	34.0	18 34
	25	36.0	18 52
	29	37.3	19 12
Feb.	2	38.1	19 34
	6	38.3	19 57
	10	37.7	20 22
	14	36.8	20 46
	18	12 35.1	+21 11

The brightness will slowly diminish but the position becomes more favorable.

Another morning comet, SCHWASSMANN-WACHMANN (2) = 1929 I, is still under observation but very faint.

COMET 1935 *d* (VAN BIESBROECK) is now disappearing in the evening sky. It was last recorded here photographically on December 20 but the low altitude makes further observations difficult. The brightness was estimated as 15^M and the object appeared as a diffuse round coma about 20″ in diameter.

How effectively the sky is recorded these days by photography is illustrated once more by the fact that pre-discovery plates of the region of this comet have successfully been searched: from Johannesburg, South Africa, comes the report that by computing the position backward the presence of the comet was located on several plates taken with the Franklin-Adams camera in the course of work on asteroids. Mr. H. E. Wood writes under date November 15: "In the case of the plates of August 5 I found that I had already measured the image as that of an unidentified minor planet. The images on the Franklin Adams plates are quite good but, owing to the small scale combined with the faintness of the object, the nebulous character of the image is not apparent." The earliest date at which the comet was recorded is July 3 at which time the magnitude was estimated at 13. The arc of observation is thus extended backward by 49 days. This will add to the safety with which the motion can be predicted for next spring when the object becomes again visible.

The year 1935 will go down as rather uneventful as far as comets are concerned: three faint comets were added to the list: 1935 *a* (JOHNSON), 1935 *b* (JACKSON), and 1935 *d* (VAN BIESBROECK). Besides there was 1935 *c*, a return of PERIODIC COMET COMAS SOLÁ.

Williams Bay, Wisconsin, December 21, 1935.

Notes from Amateurs

Amateur Telescope Makers of Chicago

The monthly meeting of the Amateur Telescope Makers of Chicago was held on Sunday, December 1, in the Adler Planetarium and Astronomical Museum, Chicago.

"Matter, Electromagnetism, and Radiation" was the subject of an address given by Mr. Wm. J. Lovejoy who is one of our members.

Mr. Lovejoy postulated the existence of an aether filling all space and described the proton as a vacuum in the aether. Twenty-nine of such vacuums or protons form an electron. Magnetism, electrical currents, and radiation are produced by the motions of the protons and electrons in the aether.

Mr. Lovejoy says that his theory is somewhat unorthodox but it was very logically presented and was illustrated by a number of colored diagrams which he had drawn for that purpose.

WM. CALLUM, *Secretary.*

1319 W. 78th Street, Chicago, Illinois, December 15, 1935.

Amateur Astronomers Association of Rutherford, New Jersey

HISTORY. The first meeting of the society was held on September 27, 1934, at the home of James S. Andrews, of Rutherford, New Jersey, and the society was formally organized on October 8, 1934. Sixteen joined in membership. Mr. Andrews was elected president, Mr. Paul J. Hagar as vice-president, and Miss Dorothy Schoof as secretary-treasurer. The society, now in its second year, has a membership of 25.

PURPOSE. The object of the society is to promote the study and knowledge of astronomy by non-technical methods for the beginner; to do definite work with observatories and scientists by the advanced student; to emphasize the cultural and inspirational value of astronomy; to interest the layman in astronomy.

MEMBERSHIP. Membership is open to any person interested in astronomy. It is not necessary to have any knowledge of astronomy or to possess any instruments or telescope.

MEETINGS. At the meetings, a paper prepared by some member is read and discussed. Each member is invited to present some topic at the meeting. Among the subjects discussed last year were the moon, the planets, especially Mercury, Venus, Mars, and Saturn, time and its practical aspects, chemistry and the chart of the elements as related to the spectrum and astronomy, astronomy of the Mayas, sun-spots, cycles, and radio, double star systems, interstellar space, how far does space extend?, and other interesting items. Outdoor observations with telescopes and study of the constellations are made when the weather permits. Two evenings of motion pictures on astronomy, held at the High School Auditorium were well attended. Special meetings have been called to observe interesting phenomena, and two field trips in conjunction with other groups of astronomers were held. A picnic and outing was held in the mountains at the end of the first season. Meetings are held twice a month at the homes of the members on the second and fourth Mondays at 8:15 P.M.

PROGRAM. To those who desire, definite, directed programs of observing are laid out. No one is compelled, of course, to follow them out, but many of our members are doing such things as variable star observing, meteor observing, and sun-spot observing.

LIBRARY. A library has been formed for the use of members. It is small, but is growing. Several members have offered to loan books from their private libraries.

EQUIPMENT. Members possess "home" made reflectors of the following apertures: one 4½-inch, two 6-inch, two 8-inch, and one 12-inch, all equipped with finders and various power eyepieces. All of these telescopes are equatorially mounted with reading circles. There are several rfractors, 2-inch, 3-inch, and 3½-inch, bi-

noculars, field glasses, and a spectroscope.

OFFICERS for the year 1935-1936 are: President, James S. Andrews, 33 Franklin Place, Rutherford, N. J.; Vice-president, Paul J. Hagar, 161 West Newell Ave., Rutherford, N. J.; Secretary-treasurer, Mrs. Alfred Bidwell, 131 Park Ave., East Rutherford, N. J.; Librarian-Historian, Willard Savary; Members of Council, Dorothy Schoof, Irving Meyer, John Loebbick.

An Amateur's Observations of Mars

Prior to the apparition of Mars this spring, the writer had accepted the beautiful drawings of the planet in astronomical books with the proverbial "grain of salt" more or less. Only through a large telescope used on a superior night by an experienced observer would such marvels be seen—such was my deduction. In other words, I despaired of seeing any detail with my equipment. However, a most pleasant surprise and revelation awaited me, and it is the purpose of this paper to pass these experiences on to those other observers who may be interested.

The present opposition being the most favorable since 1928, I made use of every good night from the middle of March to the middle of May. During this interval the entire surface of Mars was presented twice to the earth. Fifteen nights were acceptable for telescopic study, which is a rather high percentage considering the generally bad weather prevalent in this locality. In all, a total of twenty-one drawings have been made, several on the same night under best conditions.

My first real glimpse of the surface detail was on March 17, near midnight. I was immediately struck with the appearance of a brilliant white spot at the bottom of the disc, tilted toward the right. The top of the image appeared brighter than the rest, nearly as white as the bottom. A broad grey band was visible stretching from east to west near the top. To the left of the right limb and near the lower bright spot was a fairly dark patch. Later I identified the lower spot as the northern polar cap, that hemisphere being turned toward the earth and in its summer. The dark patch close to it was the Mare Acidalium. The broad streak at the top turned out to be Mare Erythraeum.

Five nights later at the same hour a totally different appearance was presented. More conspicuous than the northern cap was a very large one at the top. And a dark funnel-shaped marking occupied the southern half of the disc, slightly to the left of the center meridian. I recognized this at once as the well-known Syrtis Major. Four nights later the Syrtis was displaced to the right and another faint patch was seen between the point of the Syrtis and the north pole. This was the Casius.

Two nights later the entire disc appeared whitish, with hardly a trace of detail. On April 13 no detail whatsoever could be seen. Three nights later the Mare Acidalium and Mare Erythraeum were again in view.

Beginning with April 21, an entire week of fine weather occurred. And most unusual of all, definition was exceedingly good on every night. A drawing was made earlier in the evening, and another later, to show the rotation and what other changes evolved. Mars reveals its surface details best at twilight. The orange color is then most pronounced and the polar caps outstanding. No glare interferes with the study.

On April 22 what I had taken for the southern polar cap appeared very bright, diagonally opposite the smaller northern one. Three hours later it was displaced to the left and was not so striking. This was proof that it was not the cap. Be-

ing to the south of Syrtis Major, it was the region called Hellas.

The rotation could be detected in half an hour; the shift about equaled the opposite shift produced by the slower rotation of Mars compared to the earth's. Of course this latter one is only observable the night or nights after a particular observation. From night to night the color of the planet differed. Sometimes it was a decided orange, and at others a faint yellow. Concerning the color of the so-called seas, a pencil shading represents them exactly. Mare Acidalium was very dark at times, the darkest of all the spots seen. The tip of the Syrtis was little less dark.

The limb of Mars was decidedly brighter than Jupiter's. At all times the disc was defined better than that of any other planet I have ever observed. Details are not to be seen at a glance though; the eye must be applied for hours at a time before one is certain of what he is seeing. Three years have elapsed since my telescope was made, and it is only after this long training that it has been possible to get everything out of it. One's eyes must truly be "educated."

Changes seen include the whitish cast to the disc on March 28 and April 13, no doubt due to clouds. The north cap is now decidedly smaller than two months ago. Needless to say, my means were insufficient and the opposition not favorable for the canals. The change in diameter, and the slighthly gibbous phase now were detected.

When the Acidalium Sea was presented to me the second time, it appeared decidedly darker than a month before, also larger. This is in accord with theory, according to which dark markings intensify in that hemisphere having a melting polar cap. Weather conditions were such that one-half of the planet was seen. Those regions known as Solis Lacus, M. Cimmerium, M. Sirenum, Titanium, etc., were obscured by unfavorable weather at the time they were turned toward the earth.

As to the means employed, my telescope is a home-made Newtonian reflector of 8-inch aperture and 110-inch focus. Usually the effective mirror surface used is 5¼ inches to cut down atmospheric disturbances and reduce a slight aberration noticed with the full mirror under a high power. Vastly increased definition overrides illumination in planetary study. For ordinary views under passable conditions a power of 160 was employed; it being the least that would produce results. For increased steadiness of the air, a magnification of 220 brought more results. Under the finest conditions an eyepiece giving 300 diameters gave the most pleasing views possible. This is 60 to the inch which is about the maximum.

The atmosphere need not be so clear for this type of observation. In fact a slight haze constitutes a distinctness of image not to be attained on a crystal clear night. Illumination of high degree is always secondary to definition. Furthermore, the full moon in close proximity to the planet aids in bringing out details too. Huyghenian oculars have been used with this telescope exclusively. In my experience this type has proven superior to the Ramsden in achromatism and has fully as flat, if not a flatter, field. Tolles are no doubt better than any other for high magnifications. It has not been my privilege to employ them to date.

An experiment was made on Mars with 450x, 550x, and even pushed to over 2000x. With the first, detail was easily seen, but the vibration spoiled the image. The second had no use at all; the third (being an extremely short focus front lens of a microscope objective) gave a fair image in the center. The dark spots could not be seen at all, but the polar caps were still visible. The image did not "break down" to a great extent even with this extreme "power."

A long-focus instrument is much preferable for this type of observation on several counts. The focal ratio is over F21 with the usual aperture, and the most obvious result is the very flat field, good to the extreme edge. This is essential when no drive is available. Also, an eyepiece of more than ⅓-inch focus enlarges 300x. Nothing less than this will produce results for me. I am speaking of Mars; Jupiter defines best with the 220x at most. The long tube presents no difficulty in use. With a step-ladder and with the telescope on the best side of the polar axis, observing is truly a pleasure.

There should be more of these relatively small aperture reflectors which the great Herschel championed. Spherical figure suffices and lessens the coma in the parabolic field of view. More exactly there is no coma in this reflector. The field of planetary study is in the hands of the amateurs largely, and to me is the most fascinating of all astronomical research.

HOWARD WINTERSOHLE.

961 Western Avenue, Covington, Kentucky, May 19, 1935.

General Notes

Dr. Homer A. Harvey, of Batavia, New York, has begun a series of papers under the general title, "The Simpler Aspects of Celestial Mechanics," which are to be published in POPULAR ASTRONOMY. The first paper will appear in the following (February) issue. Dr. Harvey is a graduate of the University of Missouri in the class of 1909, has had some years of experience as a teacher in two large universities, and is now a practicing physician. He has taken up the study of astronomy as a hobby, and believes that, by easy stages, anyone can be inducted into those phases of astronomy which require a mathematical setting. He further believes that the pleasure and satisfaction which ensue from a study of this kind more than repay for the necessary effort.

We are pleased to coöperate with Dr. Harvey in an attempt to demonstrate his point of view to the readers of POPULAR ASTRONOMY.

The Rittenhouse Astronomical Society of Philadelphia held its monthly meeting on Saturday, December 7, in the Hall of The Franklin Institute. The title of the address was "Earthquakes" (illustrated) by The Rev. J. Joseph Lynch, S. J., Director of the Seismic Observatory, Fordham University.

The Rittenhouse Astronomical Society, in addition to its regular monthly meetings, has arranged a series of visits to nearby observatories. Friday evening, November 22, 1935, a party of twenty-five motored to the Princeton Observatory where they were received by Professor R. S. Dugan. The 23-inch, on its new mounting by Fecker, was carefully inspected as Professor Dugan explained the convenient electric controls and the excellent optical features of the instrument and its adjustments. Heavy clouds prevented the visiors from enjoying a view of a binary or an interesting nebula, but it was a great satisfaction to them to become acquained with the most recently mounted large equatorial in the Philadelphia area, and to note the new features of the mounting which secure ease and accuracy of control.

Dr. J. T. Rorer, President of the Rittenhouse Astronomical Society, thanked Dr. Dugan on behalf of the visitors for the very enjoyable and instructive evening.

Book Reviews

Consider the Heavens, by Forest Ray Moulton. (Doubleday, Doran & Company, Garden City, New York. $3.50.)

Many books on astronomy and on related sciences have appeared in the last few years both in Europe and in America. Through these the lay reader is able to gain a comprehension of the new and sometimes startling hypotheses and speculations with which the leaders in present day science are concerned. The new theories oftentimes are so unexpected and, to the average person, seem so revolutionary that he is inclined to dismiss them as entirely imaginary and totally unrelated to reality as he pictures it.

It, therefore, is an event of great significance to those interested in science as outsiders when a book appears, written by one who by temperament, experience, training, and mental power is qualified to set forth an opinion regarding the body of scientific facts disclosed and the conclusions drawn from them within the last decade. Such a book is the one before us.

Even though the authority of the writer were not so widely recognized as it is in this case, a book with a title so happily chosen would most certainly commend itself. If in addition, one has the good fortune of an acquaintance with the author, and even has had the rare privilege of having come into close contact with him as a teacher, then the appeal of the book becomes irresistible. Such is the case with the writer of this review, and he can heartily testify to the fascination of the volume and the exhilaration produced by it.

The author has produced a number of textbooks of the highest order. This is not a textbook in astronomy but certainly no formal text of equal size could contain a greater array of facts, expertly organized, carefully reasoned, and intelligibly presented. Dr. Moulton moves with a freedom, born of a mastery of the subject in hand, among ideas now simple now the most complex, now familiar and easily understood now the most profound, now related to that which is near at hand now to that which is inconceivably remote, all in a literary style which alone is ample justification for the volume.

One cannot convey an adequate impression of the breadth and the depth, of the charm and the grandeur of this volume without quoting from it. Consider, for example, the sheer beauty and the tremendous sweep of the paragraph on page 301. It is a part of an introduction to a consideration of questions related to the irreversibility of nature and the finite or infinite duration of the physical universe, and contains the keynote to the final chapter which is entitled "All Things Change."

> "Dawn unfolds into day and day flows onward into night; the seasons run through their longer cycles. Yesterday this flower 'was the dust, the sunshine and the rain'; today it is a dew-drenched rose, 'but you will ask in vain tomorrow what it is.' The child becomes the man; his hair is white with the snows of many winters; his gravestone crumbles into dust. One day there are gardens hanging in the clouds; 'then all is gone, and Babylon is a memory and a mound.' Once that proud philosophy was a glowing light and that religion a guiding star; their flames burned out to embers; their ashes are lifeless and cold. Yesterday this black coal stored up in its chlorophyll cells the glory of the sun; today it travels a wire and becomes a light; tomorrow it will be speeding through the depths of space toward the stars. This limestone and this marble, once the framework of lowly life but now of terraced towers, will crumble and dissolve into air."

One might open the volume almost at random, especially in the later chapters,

and find paragraphs of equally high quality.

When the psalmist used the phrase "consider the heavens" he undoubtedly had in mind the few thousand stars which he could see with unaided eyes, and he attempted to convey to others the deep impression which these heavens made upon him. The heavens this book asks us to consider transcend the heavens of the psalmist a the ocean transcends the drop. Moreover, and more surprising still, the heavens of the psalmist transcend the heavens of this book as the drop transcends the proton, a word common today but unknown to the psalmist. In other words these heavens extend in an infinite sequence above and in an infinite sequence below those of the psalmist.

The average mind reels in the presence of these stupendous concepts and would falter and fail were it not for the gentle leading, the clear understanding, and the inescapable logic of the author. Surely one's thinking can never again be inclosed within narrow limits after a reading of this book.

The volume deserves a place in the very first rank among scientific writings.

Eclipses of the Sun, by S. A. Mitchell. Fourth Edition, revised and enlarged. (Columbia University Press, New York City. xvii +520 pp. Price, $5.00.)

The Third Edition of this standard work on *Eclipses of the Sun* was published in 1932. Since then, there have been but two total eclipses of the sun, those on August 31, 1932, and on February 14, 1934, and no strikingly new theoretical contributions to the interpretation of eclipse phenomena. It is not surprising, therefore, to find that Dr. Mitchell has contented himself, in this new edition, with making minor corrections to the earlier one and with adding a chapter to deal specifically with the two eclipses just named and the results so far obtained from observations made at them.

It was the privilege of the present reviewer to review also the Third Edition,[1] and to recommend it to eclipse observers and students of solar physics and also to the general reader. It will not be necessary, therefore, to dwell upon the merits of the text as a whole, but will suffice to repeat that it gives an adequate historical summary of early eclipses, treats modern eclipses and eclipse expeditions in more detail, particularly the nine expeditions of which Dr. Mitchell was a member, and outlines the methods of predicting and verifying eclipses satisfactorily. The chapters on the *Spectroscope* and on the *Surface of the Sun* are also satisfactory and as full as could be asked in a work relating primarily to eclipses. The account of modern theories of the structure of the atom is also complete enough to indicate clearly their application to the interpretation of eclipse phenomena on the one hand and to show the need of further eclipse observation on the other.

This last point is emphasized in the new chapter, describing the eclipses of 1932 and 1934, with which the book closes. Even though wave-lengths of the principal green and red coronal lines ($\lambda\lambda$ 5303 and 6374) may now be accurately measured when the sun is not in eclipse, by the method devised by Lyot of the Meudon Observatory, it will, for example, still be necessary to depend upon eclipse spectrograms for accurate wave-lengths of the other coronal lines. Further, our knowledge of the flash spectrum is still far from complete.

In this connection, it is satisfactory to note that Mitchell (page 510) clarifies his earlier recommendations for future work (pp. 294-298) "by urgently recommending the use of both fixed and moving plates for securing photographs of the flash spectrum." Opinions of experienced observers as to the relative merits of

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[1] *Publ. A.S.P.*, **45**, 62, 1933.

the two methods still differ widely and it is therefore wise to continue the use of both.

It is also gratifying to the present reviewer to find commendations of the "jumping-film spectrograph," a new instrument used by the Lick Observatory party at Fryeburg, in 1932, and of Wright's use at the same eclipse, of 5-inch lenses of 15-foot focal length, on an equatorial mounting, for securing direct photographs of the corona. Mitchell thinks, however, that there is still "much to be said in favor of securing photographs of great scale by tower telescopes," even though he agrees that "the definition obtained by Wright in 1932 is quite up to the standard set by Marriott at the 1930 eclipse." The definition of Marriott's photographs, secured with a long focus tower telescope, in Mitchell's opinion, had never been surpassed.

The reader will close the volume with a feeling of gratification that so much has been accomplished during the few available minutes of totality (less than an hour, in all, for the successfully observed eclipses since 1900.0), and of assurance that the experience gained at the last few eclipses has made it possible to plan future observing programs with a clearer understanding of the problems still awaiting solution and of the best methods of attacking them.

Berkeley, California, December 10, 1935. R. G. AITKEN.

The Earth Among the Stars, by Marion Lockwood and Arthur L. Draper. (Basic Books, Inc., New York City.)

This is a small-sized volume of less than one hundred pages, the authors of which are in close touch with a large group of amateur astronomers and consequently qualified by experience for presenting the elementary aspects of astronomy in an intelligible manner. There are eight chapters, entitled as follows: The Earth among the Stars, The Solar System, The Interstellar Messenger, The Stars, The Milky Way, The Spirals, The Universe, Astronomy for Amateurs.

From these titles it is apparent that the book is made up of the material with which the beginner is necessarily interested. Moreover, the several topics listed are discussed in a most interesting manner, and one's attention is held by the clear and fascinating style. The writers have gleaned the salient facts and theories which have recently come into vogue. They give the reader a first glimpse and encourage him to go to more extensive writings in case he wishes further information. Certainly a child interested in the sky or an older person beginning an acquaintance with the stars will surely find much help and satisfaction in this small volume. The volume is attractively bound and contains many illustrations of the most surprising of the objects revealed by the telescope.

Astronomy is the name of a booklet of forty-eight pages, compiled by Frederic J. Haskin, founder and director of the Haskin Information Service, Washington, D. C. This booklet consists of a large number of questions pertaining to various phases of astronomy and brief, succinct answers to them. It is intended primarily as a hand book of reference for newspaper editors, and is, indeed, very well adapted to its purpose. Because of the great interest developed recently by the reading public in general scientific work, this booklet will certainly fill an important place in being a source from which reliable information may be gleaned quickly concerning the phenomena of the heavens.

Copies may be secured at ten cents each from Frederic J. Haskin, Director, Washington, D. C.